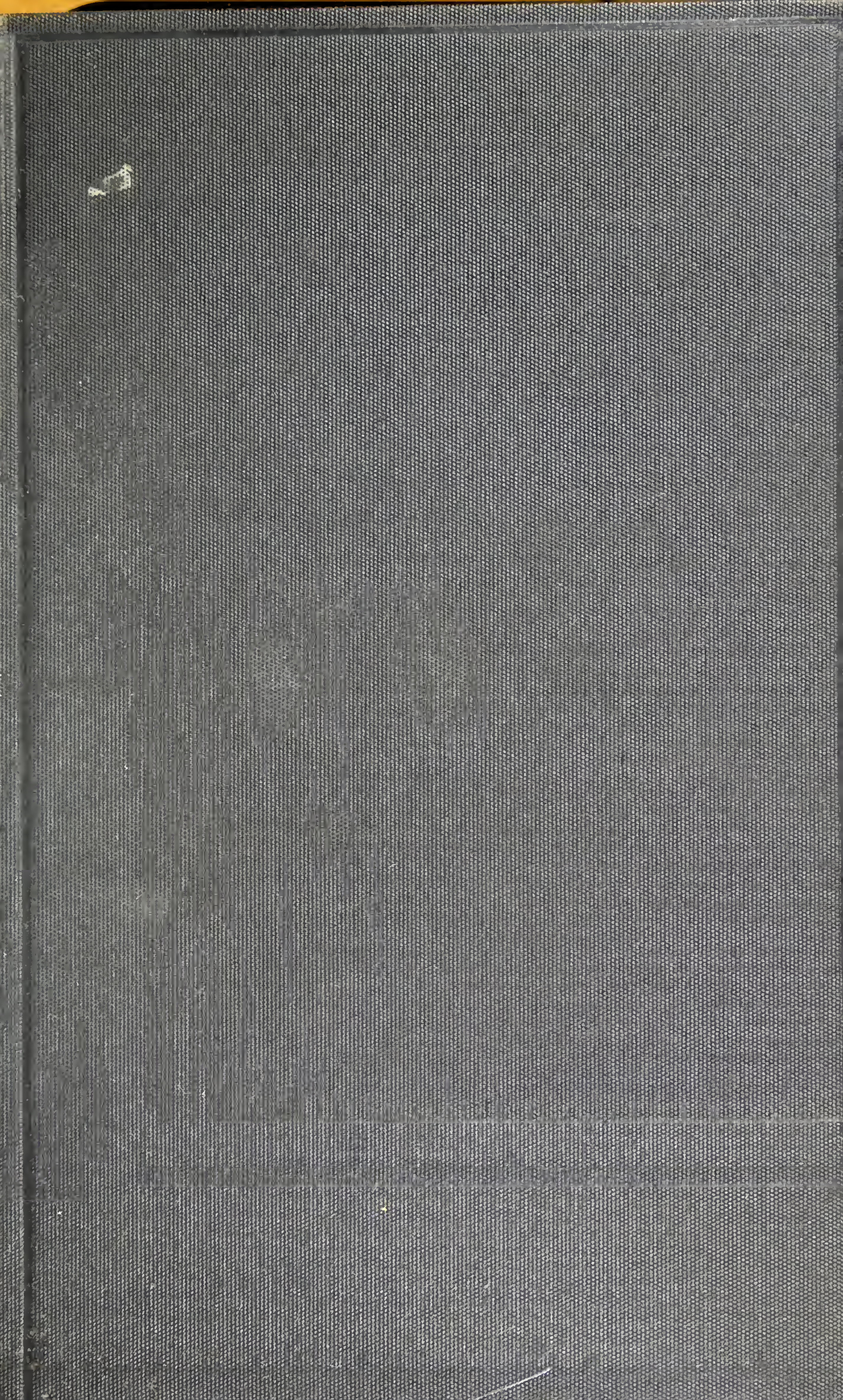


ORTHOPÆDICS, GYMNASTICS, AND MASSAGE

HYDROTHERAPEUTICS

VON ZIEMSSEN'S

HANDBOOK

OF

GENERAL THERAPEUTICS

IN SEVEN VOLUMES—VOL. V.

GENERAL ORTHOPÆDICS, GYMNASTICS AND MASSAGE

BY

PROFESSOR DR FRIEDRICH BUSCH



HYDROTHERAPEUTICS

BY

DR W. WINTERNITZ

LONDON
SMITH, ELDER, & CO., 15 WATERLOO PLACE
1886

TRANSLATOR'S PREFACE

TO

ORTHOPÆDICS, GYMNASTICS, AND MASSAGE.

THIS work being an elaborate essay rather than a systematic treatise upon Orthopædics, the reader must not expect to find in it an exhaustive description of every kind of deformity which orthopædic surgeons have to treat; but that it is a valuable work must, I think, be admitted by all.

Without attempting to discuss those subjects which might be considered open to controversy, I have added a few brief notes and references.

I must express my obligation to Dr. E. J. EDWARDES, to whom I am greatly indebted for his thorough supervision of the translation.

NOBLE SMITH.

QUEEN ANNE STREET,
LONDON, W.
1885.

TRANSLATOR'S PREFACE

TO

HYDROTHERAPEUTICS.

To say that the translator's work is a labour of love and a difficult one would be but a trite expression when applied to a German scientific work, yet in the case of Dr. Winternitz's article it has been only too true a one; and the reader who has had the opportunity of seeing the original will agree with the Translator that a more difficult task than that of giving a good idiomatic English version of the gifted Author's beautiful language could not well be conceived. The Author has in the case of hydrotherapy been the modern pioneer, and, conscious of his own merits in that science, has produced a work which for explicitness and scientific character has no superior. Let no poor, narrow-minded mortal now exclaim, 'The allopath knows nought of hydropathy; it is an unexplored territory which he dares not trespass upon, for he has no scientific basis whereon to go, and therefore cannot reconcile hydriatic measures with rational medicine' (which is, given in a nutshell, the substance of the most forcible arguments hitherto levelled against the adoption of the water cure by the officinal school), for now we have Winternitz's work; and it is to be hoped that he has not spoken in vain. He has

shown us how in the smallest household those powerful methods of lowering temperature by the aid of water, and consequently of saving life, may be adopted without much inconvenience ; and then, again, how, by the exercise of a little ingenuity upon the part of the engineer, every hospital may be furnished with the means of applying the most potent hydriatic remedies, skilled attendance, of course, being the only further absolute requirement. Yet how easily could that be obtained! By a little exertion at first any physician can train an intelligent servant or nurse to become as useful a bathing attendant as could be desired, the one requirement which is absolute being implicit obedience The Translator has trained his own servant, a half-caste Portuguese, to such a pitch of perfection—and that on board ship, too—that he need now only intimate the procedure he wishes carried out in order to have it most faithfully attended to. Without permanent personal supervision, he can rely upon a high temperature being reduced by a number of degrees fixed by himself on merely intimating as much, and the reduction of an inflammation by means of water he seldom requires to inspect. These matters, though apparently trivial, yet show that, confidence once established therein, the march upwards of the water cure to one of the most prominent positions ever held by a therapeutic agent must be both sure and rapid. But it is hardly necessary for the Translator to add his mite to the overwhelming amount of physiological and practical proofs Dr. Winternitz has furnished in this his most recent work. When in Colombo, some time since, the Translator was filled with pleasure at hearing of the most heroic feat which had ever been attempted in that part of the world, namely, the reduction of an excessively high temperature by means of the cold bath, and the saving of the

patient's life thereby, when other practitioners had given him over. The daring physician who had ventured to do this has now the reputation of being fond of heroic measures, but is nevertheless deservedly popular. However, it takes such a time for a therapeutical fact to gain ground that since 1804, when Currie published some of his results, the fact of a cold bath administered *secundum artem* being a certain means of reducing pyrexia had only travelled as far as Ceylon by 1883, probably having overleaped various other places in its journey so far!

In the pious endeavour to render the translation as nearly as possible in the Author's own style, the Translator fears he has now and again offended against the laws of idiom slightly; but this he hopes will be excused him, as that can hardly be considered a translation which will be practically a rewritten work if elaborate syntax is to be the fixed rule without departure. The greatest difficulty has been to find English equivalents for certain German phrases and words which, from our previous ignorance of hydrotherapeutics, have not become general in medical terminology, and will therefore now strike the reader as unfamiliar. Better terms may perhaps be in use at the 'hydropathic institutions,' but the doors of these have hitherto remained unopened to the student, and it is unlikely that they will now be induced to give medical science an opportunity of criticising their procedures.

MELBOURNE: *December* 1885.

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GENERAL ORTHOPÆDICS, GYMNASTICS, AND MASSAGE.

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INTRODUCTION.

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GYMNASTICS is the general name for every kind of systematically regulated movement of the body. Derived from γυμνός,

naked, it means literally ἡ τέχνη γυμναστική, the art of regulating systematically the movements of the naked body. Among the Greeks the Doric race, and especially the Lacedemonians and Cretans, were foremost in providing for the culture and development of the body by exercises, and were also the first to recognise and introduce nudity as necessary in gymnastics; subsequently all the other Hellenic races followed their example. In the naked state the whole surface of the body could be oiled, and thus could attain a degree of lissomeness and suppleness which could not be acquired in any other way; further, nudity enabled the spectators to observe accurately the play of the muscles, and afforded to artists an exceptional opportunity for study, materially helping to raise Greek sculpture to its unparalleled height of excellence. The naked state was from this time not an element of slight importance in Greek gymnastics; far otherwise, it was an essential and even integral part of these exercises, and with justice deserved the name it acquired for itself of ἡ τέχνη γυμναστική. In later times the name was changed, and Galen especially uses the word *κίνησις*.

Gymnastics, as a general collective name for every kind of systematic bodily movement, was again subdivided as follows: first, *competitive gymnastics* (or 'agonistik,' from ἀγών, a contest); secondly, gymnastics raised to the highest degree of strength, or *athletics* (from ἄεθλος, contracted to ἆθλος, labour, contest); and thirdly, *acrobatics*,[1] the development of complicated combinations of movements calculated to display the suppleness of the body in the most favourable manner. If we separate these groups, each of which in the course of time has attained to an independent existence, gymnastics appears as the art most effectually adapted to bring the strength and lissomeness of the body to the highest pitch of health and beauty. Its purpose is to prepare men for special aims, and it is a means for attaining the highest degree of bodily and mental beauty and vigour. It is precisely in this sense that gymnastics, as practised by the Greeks, have been unattained by any other nation, and are

[1] Acrobatics, derived from ἀκροβατεῖν, to go on to the top; ἄκρος, high; and βατεῖν = βαίνειν, to go.

even more to be admired on that account than because of the enormous exhibitions of strength which were displayed. In this limited sense gymnastics may be divided into active movements in which the individual uses his own muscular power; and passive movements, in which the individual is moved by outside force—that is, either by the hands of men trained for the purpose (*pædotriba*, *gymnastes*) or by powers of another kind. Passive movements of the latter sort are, for example, the different kinds of travelling in carriages, ships, &c. Riding, on the contrary, is a mixed movement, since on the one hand the individual is carried forwards by the strength of the horse, while on the other hand he must sustain himself by his own muscular energy in order to preserve his seat on the back of the animal.

The movements of the body of the patient imparted by the hand of a trained gymnast can only be either of the kind which affect the normal mechanism of the joints, such as flexion, extension, abduction, adduction, &c., in the different joints (passive movements in the narrowest sense), or have nothing to do with the joints and consist only in pressure or rubbing, applied to different parts of the body. Movements of this sort were named by the Greeks *Anatripsis*, by the Latins *Frictio*, and more recently are generally called by the French name *Massage.*

As it is the object of this work to decide the question what use can be made of these different kinds of movements for the preservation and restoration of health, it is needful, in the first instance, to glance at the different methods of gymnastics as evolved amongst the nations who have most developed them, and as a matter of course we begin with the Greeks.

The Greek gymnastics were most intimately connected with the sacred games, amongst which were the prize contests in the different varieties of exercises. These were Nemæan, Pythian, Isthmian, and above all others the Olympic games. Greek gymnastics began to develop with the initiation of the Olympic games, flourished co-temporaneously and finally disappeared with them.

The date of the establishment of the Olympic games is lost in the midst of ages, and tradition names Hercules as their

founder, he having instituted, on the site of the later Olympia, a race in which he himself was the victor.

After a period of fabulous legend, the historical time of the Olympian contests begins with Iphitus, who arranged the festivals (before only irregularly conducted, and indeed for a time quite forgotten) in a definite manner. The result was that they were held every fifth year. The principal means by which Iphitus obtained this regularity was by the institution of the sacred truce (*ἐκεχειρία*, or *armistice*). This consisted in the proclamation of a truce from war during the month in which the festival took place. The beginning of the sacred month (*ἱερομηνία*) was announced by the heralds of peace of the people of Elis in their own land first and afterwards in the other Hellenic states, and with the first day of this month every Greek could repair to the festival unhindered and fearless of harm.

After a secure foundation for the holiness of the festival had been secured in this manner, the series suffered no interruption, but the full light of history only falls upon them some time later, when the victors in the different contests were distinguished, and the Olympiads began to serve as chronological data. This was in the 28th Olympiad (108 years after the re-establishment of the games by Iphitus), in which Corœbus of Elis triumphed (in the year 3938 of the Julian period, 23 years before the building of Rome, and 777 years B.C.) In the 6th Olympiad the victor was adorned with the crown, by the decree of the Pythia, the games becoming thereby *στεφανίτης*.

The victor received a crown of wild olive, and also, as in all sacred games, a palm branch, which he held in his hand; this last, as Plutarch believed, because the palm is an emblem of strength, inasmuch as, whenever bent, it immediately returns to an upright position.

The Olympiad in which Corœbus was the conqueror was reckoned anew as the first, and thence followed an uninterrupted series of 286 sacred festivals. In the year 369 A.D. the Olympic contests (which had been discontinued for some time) were re-established by the Emperor Valens Augustus. In the 16th year of the reign of Theodosius the games finally ceased,

293 Olympiads after the first festival, in which Corœbus was victor. This happened in the year 394 A.D. Two years afterwards the Alaric hosts overran the Peloponnesus and destroyed the splendid treasures of art which a thousand years of undisturbed development had accumulated. In Greece the Olympic festivals continued to be held throughout all national changes, from a fabulous antiquity to its final destruction as a kingdom. Since the re-establishment of these games by Iphitus, 1,279 years had passed, and 1,171 years since the first Olympiad (Corœbus). With these games the Greek nationality developed, with them it flourished, and with them it fell, a clear proof of the intimate connection between the two, and also of the influence exerted by practically directed gymnastics upon the wellbeing of a race.

The Olympic festivals consisted of various gymnastic competitions (*ἀγὼν γυμνικός*) and horse races (*ἀγὼν ἱππικός*). A musical contest (*ἀγὼν μουσικός*) was added to the Pythian, Nemæan, and Isthmian games, but not to the Olympic. Nevertheless, celebrated poets, such as Lysias and Lucian, recited their works (but not in competition) at Olympia to the assembled Greeks. Only Greeks who were free and in full enjoyment of all their rights as citizens might appear as competitors for prizes (later on Romans also); barbarians were only admitted as spectators. Matrons were forbidden to look on at the games under severe penalties; maidens, however, were, strange as it appears, admitted. The looking on at these games was in itself a trial of strength, for they took place in the hottest month of the year (in the time of the summer solstice), and the spectators were obliged to sit with uncovered heads.

The gymnastic contests in connection with the festival games were at first few in number, but in the course of time increased considerably. In the time from the re-establishment of the games by Iphitus to the commencement of the Olympiads of history, the simple race (*δρόμος*) formed the only competition. In the 14th Olympiad the double course (*δίαυλος*) was added, which amounted to twice the distance of the first, and in the following Olympiad the *δόλιχος* was introduced, a long race several times as long as the *δίαυλος*.

In this Olympiad also complete nudity was enjoined as a necessary condition, whereas before a girdle (περίζωμα) had been permitted. In the 18th Olympiad wrestling and the contest of the five games (*Pentathlon*) were instituted; in the 23rd Olympiad boxing was introduced; in the 25th racing with four full-grown horses abreast (ἵππων τελείων δρόμος). In the 33rd Olympiad appeared the first *Pancration*, or complete contest, and at the same time racing on horseback was begun (ἵππος κέλης). In the 37th Olympiad prizes were first awarded to boys for running and wrestling. In the 41st Olympiad boxing began for boys, and in the 65th running in armour. The team of mules was introduced in the 70th and racing with mares in the 71st. In the 93rd Olympiad racing with two full-grown horses began (ἵππων τελείων συνωρίς); in the 96th the contests between heralds and trumpeters; in the 99th the races with teams of four foals (πώλων ἅρμασι); in the 131st also with single foals (πῶλος κέλης), and in the 145th Olympiad the *Pancration* (complete contest) of boys.

Through this increase to the contests the Olympian games, which at the beginning had only lasted one day, were lengthened to five days. This time was not, however, entirely occupied by the gymnastic encounters, there were also sacrifices and festal processions. Let us now consider briefly the most important of the gymnastic contests; and we naturally begin with the most ancient, namely, *racing*, in its different forms.

1. The *simple race* (δρόμος) consisted in a single run over the whole course (στάδιον), which measured 1,000 feet. The usual length of the stadium was 600 Grecian feet = 625 Roman = 569 French = about 180 metres. The double race (δίαυλος) had to cover this course twice, the runner proceeding on one side of the stadium to the goal, round which he ran in a short circle, returning on the other side of the stadium to the starting point. In both kinds of race the competitors ran either in a state of complete nudity or encumbered by weapons (ὁπλιτῶν δρόμος). The long race (δόλιχος) extended to a much greater length, varying between seven and twenty-two stadia. This performance required an extraordinary effort, and not unfrequently led to the death of the competitors from exhaustion. The

competitors training as runners required strong legs but narrow shoulders. For this reason Socrates condemned the exercise, as not developing and strengthening the body equally. The race with weapons was at first run with shield, helmet, and leg greaves, later on with the shield only. In earlier times the racers did not, it would seem, anoint their bodies with oil, for in the contests recorded by Homer the use of oil is not mentioned. When, however, in the 15th Olympiad, the last vestige of covering during the race, viz. the girdle (*perizoma*), was thrown aside, the oiling of the whole body of the runners was adopted. The contests between boys in the Olympian games consisted only of the simple δρόμος. The quiet walk (περιπατεῖν) was recommended by Greek physicians as a means of maintaining health. In many parts of Greece the maidens also ran races, but not in Olympia itself. Plato directed nudity for the latter up to the age of 13, and from 13 to 20 the wearing of a suitable garment.

2. *Leaping* (ἅλμα) formed no competition by itself, but was an essential part of the *Pentathlon* (see below), and finds here its most natural connection with the race. For help in leaping, the Greeks used leaping weights (ἁλτῆρες), that is, weights of lead or iron, something like our bar-bells, which were grasped one in each hand, and by the throwing forwards of the arms increased the speed of the body. As the distance which the Agonistes covered in their leaps was not seldom 50 (29½ English) feet, and was without a run, we may very well assume that the leap must have been taken from a raised standing place (possibly from a spring board). In the leap likewise the body was naked and oiled. Dumb bells were used in the same way as our 'bar-bells' in the Palæstra in the various strengthening gymnastic exercises, and are mentioned in the gymnastic dietetics of the later Greek physicians, Galen and Antyllus.

Aretæus recommends, in addition to other bodily exercises, swinging with the jumping weights as a remedy for chronic headache.

3. *Wrestling* (πάλη). According to mythology, Πάλαιστρα, daughter of Hermes, invented wrestling.

The Homeric heroes carried on wrestling dressed with the

perizoma, but without their bodies being oiled. In the 15th Olympiad the use of the girdle was discontinued and the body of the wrestler was anointed and sprinkled with the dust of the Palæstra. The oiling was under the care of attendants specially appointed to this office, viz. the Aleiptes. At the same time the loose epidermic scales were peeled off by means of a curry comb, the *stlengis* (*ξύστρα*, *strigilis*), so as to keep the surface of the body smooth and supple. Fixed rules regulated the wrestling, restricting it to movements considered permissible and graceful. In standing wrestling (*πάλη ὀρθή*), the thrown combatant was allowed to rise and return to the contest. Whoever was thrown three times was conquered. In the rolling wrestling (*ἀλίνδησις*), the combatants contested while lying on the ground, until one or the other was declared conquered. The last species of contest, however, was not only carried out in Olympia but formed also a part of the *Pancration*. Also, from a medical point of view, a certain sort of wrestling was recommended by physicians of a later date, such as Antyllus, especially as a remedy against obesity.

4. *Disk throwing* (*δισκοβολία*). The disk was a plate of brass without a handle and of considerable weight. It was thrown from the right hand into the air, the thrower standing on a raised place, and the spot marked where the disk first touched the ground. Whoever threw his disk the farthest was the victor. The disk was not thrown at any kind of mark. In this sort of contest also the performances were marvellous: the Cretan Phayllus threw his disk 95 feet.

5. *Javelin throwing* (*ἀκόντιον*). In this case the javelin was thrown at a fixed target, as a preparation for war and hunting. This exercise especially improved the strength and facility of the right arm, sharpened the eyesight, and gave to the whole body a fine manly carriage.

6. The contest of five (*πένταθλον*) included all the five above-mentioned gymnastic exercises. The object of this combination was that the body should not only be trained for one special sort of contest, but as harmoniously as possible, so that strength and dexterity should be equally balanced.

Jumping, disk throwing, and javelin throwing alone were carried on in the *Pentathlon*; racing and wrestling formed

separate contests. The race in the *Pentathlon* was the single stadium or the double race without being handicapped by weapons. The order in which the different performances followed one another is not known for certain, but Böckh's account seems the most probable. According to him the *Pentathlon* began with leaping, then followed the racing, then disk throwing, then spear throwing, and wrestling formed the conclusion. This order is alluded to in the ancient verse:—

ἅλμα, ποδωκείην, δίσκον, ἀκόντα, πάλην.

Leaping was accompanied by the music of flutes. It is a matter of uncertainty whether it was necessary, as Burette and Hermann believe, that in order to obtain the 'crown' the competitor had to be victorious in all five divisions, or whether the one who was victorious in the greatest number of contests received the prize.

Aristotle describes the *Pentathlon* as the finest contests, because strength and agility were equally required. Also, medically considered, the *Pentathlon* was highly prized.

7. *Boxing* (πυγμή) surpassed all the above-mentioned performances in the gravity and danger of the contest, since the powerful blows of the fist enveloped in thongs (*ἱμάντες*, cestus) inflicted severe injuries. The heads of the boxers were therefore for the most part covered with scars, and the ears, being particularly exposed to injury, were generally mutilated. The extravasations of blood in the muscles of the ear, which finally underwent cicatricial contractions, are known by the name of 'othæmatoma.' Also the teeth, the nose, and the chin were much exposed to injury. Celebrated boxers were on this account represented in statuary with crippled ears (*ὠτοκάταξις*). 'Closing in' and wrestling were not permitted in boxing, which was, on the contrary, restricted exclusively to blows with the armed fist. The wilfully killing of one opponent by the other was strictly forbidden, and if such an act was proved to be intentional, then the victor's crown was not given to the survivor, but ascribed to his dead opponent. When one combatant recognised his defeat he signified it by holding up a hand.

From the great strain upon the muscular powers, the adroit evasion of the attempted blows, the swiftness in returning them, and the habit of meeting threatening danger with a calm eye and steady hand, boxing served especially as a preparation for battle. For medical reasons this exercise is naturally not suitable, and it is incomprehensible how Aretæus can have recommended it for giddiness and chronic headache.

8. The *Pancration* (*παγκράτιον*, *complete exercises*) was still more dangerous and alarming than boxing, because in this exercise, in addition to blows with the fist, any other attack upon the opponent was allowed. In consequence of this much-increased danger to life, only the strongest athletes ventured to engage in it. As the hand was obliged to remain free in order to seize the adversary it was not wrapped round with thongs, and therefore the blow of the fist itself was not so dangerous, but the contest was pursued with extreme acrimony and without cessation until the antagonist acknowledged himself beaten by raising up a hand. If both combatants fell to the ground, no interruption to the fight took place, but each endeavoured, by clutching, pressing of the windpipe, breaking and twisting the fingers and toes, &c., to induce his adversary to give up the contest. Biting alone was forbidden by the rules of the fight. To conquer both in wrestling and the *Pancration* on the same day in the Olympian games was the highest attainable athletic feat. After Hercules, who was the first to accomplish this, there were only eight other combatants in the whole course of the Olympiads who reached this pitch of excellence, and who consequently received the title of Heraclides. The victors in one of the four sacred games (*ἱερονείκης*) were heaped with honours in their native cities. If, however, one had been successful in all four sacred games, his fame as *περιοδονείκης* was still greater, and became known wherever the Greek language and customs existed. One of the most celebrated Periodonikes was Theagenes of Thasos, who, according to Plutarch, gained 1,200 crowns, partly in the four sacred games and partly in other contests.

9. *Chariot racing* does not take the same position, from a gymnastic point of view, as the other exercises, since the possessor of the carriage was not himself obliged to drive the

horses, but could nominate a friend to do so ; nevertheless, in the event of victory, *he* received the prize for the performance of his horses and driver. When Alcibiades had in this manner won the victory, Agesilaus determined to send his sister Kyniska at the next celebration of the Olympic games to drive a chariot with two horses, in order to show, if she gained the victory, that success in chariot racing was not a proof of manly strength and personal skill, but only an evidence of riches and expenditure. She won ; and after her several Lacedæmonian and Macedonian women did the same.

10. *Races ridden on full-grown horses* (ἵππῳ κέλητι) *and colts* (κέλητι πώλῳ) were held in high honour in the great festival games, and powerful kings, such as Hiero and Philip of Macedon, competed and won in this kind of contest. The introduction of riding into the sacred games must have been simultaneous with the employment of cavalry in war. In the heroic times, and even for long after the Trojan war, the Greeks used fighting chariots exclusively in battle, and never fought on horseback. In the time of the Persian war, however, fighting from chariots was quite abandoned by the Greeks, and the use of cavalry was substituted. The chariot was then only used by the Greeks in races and other peaceful pursuits, and they were only used in battle by barbarians. The saddle proper and stirrups were unknown to the Greeks, and they rode only upon a cloth laid upon the back of the horse and kept in place by a girth. Plato estimates riding very highly as a preparation for war, and most strongly recommends this exercise. Pliny praises its beneficial effect upon the digestive organs and its strengthening action on the chest, flanks, and thighs. According to Antyllus, it is not only good for the stomach but also purifies and sharpens the organs of sense ; on the other hand, he considers it hurtful to the chest. The opinions of Aristotle and Hippocrates as to the effect of riding upon the sexual instinct are very different. Aristotle thought that it excited, because by it the genital organs were heated and were even enlarged with increasing age. On the other hand, Hippocrates maintains that continual riding may even cause impotence (as well as sciatica and podagra). From a medical point of view, riding was highly esteemed even in the

time of Socrates. Galen remarks that boys may begin to ride as soon as they have completed their seventh year.

Shooting with the bow (τοξοσύνη) had no place in the Olympian games.

Fighting with weapons (ὁπλομαχία) was never practised in the Greek games of historical times; but was carried on, according to Homer, in the games which were held at the obsequies of Patroclus.

Hunting (κυνηγεσία) was valued for both medical and athletic reasons. The story runs that Asclepias, Machaon, and Podaleirios, who were sucklings of the Centaur Chiron, became celebrated huntsmen. Plato and Xenophon both wrote in praise of hunting.

Bathing and Swimming were highly esteemed by the ancient Greeks. Warm baths were necessary for the purpose of cleansing the body from oil, perspiration, and the dust of the Palæstra, and therefore were always indulged in at the termination of the gymnastic exercises, and the repast followed the bath. At a later period in Greece, when the old customs were gradually falling into disuse, the luxurious warm bath became customary and enervated the body to a very great extent.

For medical purposes, sweating baths with dry hot air were in use in Sparta at an early date, and after their introduction among the Romans were called Laconicæ. The cold bath and swimming in rivers and in the sea were also much practised, and Aristotle thoroughly explains why swimming in salt water is easier than in fresh. The importance attributed to swimming as a bodily exercise was shown by the proverb μήτε νεῖν μήτε γράμματα (*nec litteras didicit nec natare*), which was used to designate those persons who enjoyed neither a bodily nor a mental cultivation.

In Rome also swimming was highly approved of, and the healthy and manly young men, after the dusty exercises in the Campus Martius, resorted to the flowing Tiber, and were refreshed and cleansed by swimming. Horace advises sleepless people to anoint themselves and swim three times across the Tiber.

Of great importance were the oiling and rubbing after the

bath; consequently oil flasks (λήκυθος) and currycombs (στλεγγίς) were necessary accompaniments of bathing. From the time of Hippocrates to that of Galen medical rubbing (not only before and after gymnastic exercises and before and after the bath, but also at different times of the day and for different diseases) was brought to so great a degree of perfection, that there were many theories advanced upon the subject, and various kinds of rubbing were distinguished.

Hippocrates, in his work 'De Articulis,' writes, 'The physician, besides being accomplished in many other ways, must also understand massage.' Massage may be used for strengthening a loose joint and also for loosening a stiff one. We shall, however, describe the details of this process farther on.

These further details are partly to be found in the part 'De Officina Medici,' which the work contains: 'Frictio si vehemens sit, durari corpus; si lenis, molliri; si multa, minui; si modica, impleri;' and this pamphlet forms the foundation for all later treatises of antiquity dealing with rubbing.

Kinetics were specially considered in the mechanical system of Asclepiades (128–56 B.C.) According to this system, the whole body consisted of numberless canals formed by combinations of atoms (provided with sensation), through which the humours of the body moved. If this process continued without disturbance, health was maintained; if the contrary, disease supervened. The normal movement of the humours, however, was disturbed by abnormal size of the atoms, by derangement of their order, by their too great number and by swiftness of movement, also by abnormal narrowing or widening of the canals. Proceeding on this assumption, Asclepiades almost completely gave up the use of medicine, and endeavoured in its place to restore free movement of the atoms by means of friction, the use of which led, amongst other things, to the knowledge of the narcotic effect produced by gentle strokings with the fingers. Frequent active and passive movements and baths, especially cold, were employed for the same purpose. *Frictio, aqua, gestatio* were his chief remedies. Celsus devotes much care to describing the '*communia remedia*,' which reached their greatest development under Asclepiades. They

were the 'frictio,' 'unctio,' 'gestatio,' 'abstinentia,' and sudorifics, also sick diet.

Galen likewise gives to 'frictio' and 'exercitatio' a position of importance in his therapeutics, and makes a clear distinction between active, passive, and compound movements. His expression, 'Pædotriba ita est gymnastæ minister ut medici coquus,'[1] is famed, for as the cook understands the preparation of meats and drinks without knowing their effect, whilst the physician knows well the effect without being able to undertake the preparation, so may the *pædotriba* be very skilful in accomplishing the movements prescribed to him by the scientific gymnast, without being able to account for the effect which they produce.

The movements performed outwardly upon the body were especially recommended by Plato for their beneficial effects, for every movement or succussion of this kind, whether it be in a swing, on horseback, or on board ship, acts favourably upon the body without producing fatigue, it improves digestion, and also promotes health and beauty. This he shows specially by the example of the Athenians, who carried their cocks and quails long distances (many stadia), to get them into the best possible condition (*εὐεξία*), and thus to strengthen them for prize contests. But we must carefully distinguish between a regular comfortable movement and a rough and violent one; that is, between a dietetically arranged procedure and the impetuous course of a race; and the physicians had good reasons for discarding the latter, since such a powerful shaking of the body might do more harm than good.

A special kind of gymnastics consisted in the exercise of the voice (*ἀναφώνησις*). Loud speaking, singing, and shouting strengthens the muscles of breathing and quickens the circulation. Demosthenes is said to have given the actor Neoptolemus 10,000 drachmas,[2] to be enabled by his instructions to utter whole sentences in one breath. Competitions in speaking and singing were very early practised in Greece, and the most ancient of these competitions were the Pythian, upon which all subsequent performances of the same kind were

[1] Ὁ παιδοτρίβης ὑπηρέτης ἐστὶ τοῦ γυμναστοῦ τοιοῦτος οἷός περ ὁ μάγειρος ἰατροῦ.

[2] A drachma is $7\frac{3}{4}d.$; therefore the sum was 322*l.* 16*s.* 8*d.*

based. With respect to the medicinal effect of exercises of the voice, the testimony of ancient physicians is not entirely unanimous. Antyllus describes it as bad for the head, but Cœlius Aurelianus recommends it unconditionally for headache. Celsus considers that such exercises are prejudicial to a weak stomach. Plutarch praises them because they can be accomplished in any position of the body, either standing or lying. Even the crying of a child is declared by Plutarch to be an important gymnastic exercise, favouring growth and being beneficial to the tender body, and he would on no account restrain it.

Laughter also has, from the time of antiquity, been extolled as a gymnastic exercise of the diaphragm, as favouring digestion and averting hypochondriasis.

Gymnastics and music have always been closely associated. The best gymnastic, wrote Plato, is sister to pure and simple music. By the one health is given to the body, and by the other self-control to the mind, so that both together form a complete education. Gymnastics alone, or music alone, produces effeminacy.

Transition from Gymnastics to Athletics.

The Olympic games, and in fact all the gymnastic exercises of the Greeks, originated in the endeavour to popularise bodily exercises with all classes of the people, and thus not only to increase their capacity for action both in peace and war, but also to raise their health, strength, and beauty to the highest possible extent. After the attainment of this end there was developed an outgrowth of gymnastics which left all other aims disregarded, and which concentrated in a definite direction the highest cultivation of bodily strength alone. The feats of strength that were especially necessary in wrestling, in boxing, and in the terrible *Pancration*, to afford any prospect of attaining victory, led to the result that a strong man who filled any civic capacity could not engage in these struggles, but a special class of men arose whose sole occupation was the attainment of the greatest possible amount of bodily strength. These were the professional athletes. Their single aim was to

win a victor's crown in the sacred games, and especially in the Olympic, and the honour and fame thus attained through all Greece, and especially in their native city, more than rewarded them for their labours. In addition to the notoriety which they obtained and the prizes which they won, the victors were frequently honoured by the placing of their statues upon the scene of their success and in the temples of their native city, and in case of necessity, the town so highly honoured through the victor undertook his maintenance at the public cost.

The honours and advantages of an Olympian victory to those who were successful were thus very considerable, but so also were the labours and fatigues without which their attainment was impossible. One of the necessities of training was the special diet (ἀναγκοφαγία). The trainers of athletes had found from observation that a certain diet was the most fitted to produce the highest degree of muscular power. This diet and the occupation produced, however, such drowsiness that the professional athletes were never able to fill satisfactorily any other position in town or home life. Athletes also appear to have been especially subject to epileptic fits. If any one had accustomed himself for a lengthened period to the diet of athletes, he incurred considerable danger to life if he forsook this diet and returned to his ordinary mode of living. For all these reasons philosophers, such as Plato and Aristotle, as well as physicians, condemned the excessive training measures of athletes. Galen, however, was the severest of all, and stigmatised them as κακοτεχνία, ill-treatment. He asserted that the mind was completely overpowered by the superabundance of flesh and blood which were produced by the diet of the athletes, so that they were not able to reflect properly—in fact did not know that they had a mind, thus resembling brute beasts.

Athletic training attracted either young people who manifested an unusual degree of bodily strength in the occupations of daily life, like the young Theagenes of Thasos, who, at the age of nine, coming out of school, carried home from the market a brass statue which took his fancy; or other young people who displayed such great powers in the exercises of the usual scholastic gymnasium, that it appeared desirable to seek their further

development in systematic athletics. Others practised gymnastics in order to restore their health and afterwards became powerful athletes, even gaining a number of crowns in the sacred games. Beside the athletics proper, medical and scholastic gymnastics were pursued unrestrictedly, and their full political importance was recognised by the most prominent philosophers. This form of gymnastics seems to have been favourable to the prolongation of life, for several greybeards amongst the Greeks and Romans have ascribed their long life to the oil of the Palæstra. Thus Herodicus, the celebrated tutor of Hippocrates, cured himself of bodily weakness and illness by gymnastics, and reached the age of 100 years.

Galen, who was delicate up to the age of thirty, restored his health by devoting several hours a day to bodily exercises, and cured a number of people from diseases and weaknesses in this manner; on the other hand, the professional athletes attained, at the best, no great age.

The diet of the athletes was altered in the course of time. At first it consisted principally of fresh cheese, dried figs and wheat. Later the eating of meat was introduced, and, according to Galen, the athletes who practised the more severe exercises consumed principally pork and a special kind of bread. Beef and goat's flesh also were used. Generally the food of the athletes was very dry. Of these provisions the athletes used to consume a very large quantity after the close of the daily agonistic exercises, after which they retired to sleep. They were obliged, by order, to pursue this regimen for ten uninterrupted months at home before each entry into the athletic contests in Olympia, and in the Olympic games each combatant was compelled to submit himself to a further preparation of thirty days, and in every respect to follow the rules of the gymnastic superintendent.

The enormous quantities of food which were consumed by the athletes may be shown from the following examples.

Milo of Crotona is reputed to have carried a four-year-old ox the whole length of the stadium, then killed him with a blow of his fist and consumed him in one day! The strong shepherd Ægon seized a steer by the foot, bore it from the mountain, and presented it to his Amaryllis, and to the astonish-

ment of the women present, he ate eighty dishes of the animal one after the other!

During the time of preparation for the contests, the Agonistes had to abstain entirely from coitus, and at all times to be exceedingly moderate in this matter. With reference to this Horace says:—

> Qui studet optatam cursu contingere metam
> Multa tulit fecitque puer, sudavit et alsit;
> Abstinuit Venere et vino.

The victor's crown might also be obtained without fighting (ἀκονιτί, *i.e.* without dust). This happened when any athlete who was named in the programme either appeared in the arena too late or did not come at all. Further, an athlete might be so dreaded that no one dared encounter him. In this case also the victory was declared ἀκονιτί.

Whoever followed the occupation of athletics up to his thirty-fifth year without gaining any victory abstained further from these conflicts, for the thirty-fifth year was considered the highest point (ἀκμή) of manly strength, after which no increase occurs. Those, however, who had gained one or more victories and wished to become well-known athletes, adhered to this career so long as they felt themselves sufficiently strong. They attended all the festival games, wore several of their prize crowns, and if they succeeded in winning the prizes in all four sacred games were honoured as *Periodonikai* in the highest degree. If they lost their strength they gave up this course of life, and in the event of poverty, lived in the Prytaneum of their native city, and were provided with food free of cost till the end of their days. The less fortunate athletes, who had obtained no wreaths in the sacred games, frequently became teachers of gymnastics.

As a branch of gymnastics was developed the orchestra. Regarded in its widest aspect, the whole Hellenic orchestral music accords entirely with the Greek character and temperament, both religious and profane. Religious orchestral music contains warlike as well as peaceful, or armed and unarmed dances, which, according to their nature, belong to different classes. Secular orchestral music embraced all the gymnastic

and theatrical dances, of which some were conducted with weapons, others without. The theatrical were divided into tragic, comic, and satirical, and at the same time embraced the whole subject of pantomime. At first the religious principle predominated in the orchestra. Thus, at every sacrifice, chorus dances with songs were performed, which consisted in light and rhythmical movements. These dances were performed sometimes in complete nudity, as, for instance, at the Gymnopædic festival in Sparta. The Bacchanalian and Corybantic dances consisted in violent movements and lively gestures. Amongst the profane dances the pyrrhic is especially to be mentioned. In this dance two rows of armed men advanced against each other with measured step and rhythmical movement, first advancing then retreating. In later years the origin and even the meaning of dances became lost, and they degenerated into merely incitements to sensuality. From a scholastic as well as a medical point of view, the warlike part of orchestral music especially predominated, for these dances, practised in the open air, were in no way inferior to the finest gymnastic exercises. Not only with reference to the preservation of health and strengthening of the limbs, but also in regard to the engendering of ability, courage, presence of mind and dexterity, these dances were of great value and essentially a means of promoting the gymnastic cultivation of the nation; moreover, in their execution, as in other gymnastic exercises, a great value was attached to beauty.

The Romans developed no national gymnastics of their own. The Campus Martius was the place for the education of the noble Roman youth in driving, riding, and chariot racing, and the last exercise occurred as a prize contest at the great festivals in the Circus Maximus before the assembled people. Further than this, however, the Roman citizens did not indulge in any public contests. There was, however, a kind of mimic combat not unfrequently performed by them, and this was the 'ludus Trojæ' or Trojan game, which, according to tradition, was founded in Rome by Æneas. This game had been completely neglected, but was revived by Julius Cæsar. The players, on horseback in full armour, divided themselves into two parties and engaged with scientific

movements in mimic battle, repeatedly retreating and again returning to the combat. The gladiatorial conflict proper took place only amongst slaves. A number of gladiators (*familia gladiatoria*) lived under the superintendence of a trainer (*lanista*) in a separate house, and were by him instructed in sanguinary contests, which were fought in a variety of ways. Only in the time of the later emperors did distinguished Romans descend into the arena. The emperor Commodus engaged so often in these combats before the assembled people, that he considered it his greatest honour to be called the first of gladiators. When Greece fell under the sway of the victorious Alaric in the year A.D. 396, and soon after, when Italy suffered the same fate, the study of gymnastics, the result of a hundred years' development, ceased almost entirely. Alexandria, where Greece had developed a colony, still maintained its power for some centuries afterwards, but in the year 640 this important city fell into the hands of the Arabs. For some time after this event the Byzantine empire maintained its sovereignty, but Greek gymnastics were no further developed nor indeed preserved, and when Constantinople fell in 1453, and the Turks conquered the whole of the Greek empire, the last vestiges of classic Greece departed.

Meanwhile, in Western Europe a new empire had developed from the migration of nations. The invading conquering tribes of the Goths, Franks, Vandals, &c. had seized upon and established themselves in the countries which had hitherto been the most highly civilised. Horsemanship and the bearing of arms naturally were held in high repute among these warlike people, and were most zealously practised by the young men, but a real system of gymnastics could not be developed under such conditions. Furious onset and vigorous attack constituted the one method of combat.

On the other hand, there was the rise of tournaments, which seem to have been developed from the Roman 'ludus Trojæ,' or from the mimic combats of the Arabs, and their introduction into Germany by Henry I. (919–936) formed the commencement of gymnastic contests carried out under systematic rules. This institution, however, met with very strong

opposition from the Church. The Church, which had already violently opposed the Grecian gymnastics, also denounced tournaments most vigorously. As deaths often occurred in consequence of these encounters, Innocent II. decreed (1130), at the Lateran Council, that those who lost their lives in the tournament should not be buried by the Church. In spite of this opposition on the part of the Church, tournaments flourished for five hundred years, and only ceased in 1495, in which year the Emperor Maximilian presided at one of the last grand tournaments. Vestiges of these combats, however, did not disappear till the end of the sixteenth century, when they gradually gave place to the harmless tilting and riding at the ring, as practised at the time of Gustavus Adolphus.

In the meantime the general political aspect of Europe had very materially changed. The victories of the Swiss peasants at Sempach (1346), and of St. Jacob on the Birs (1444), as well as of the English archers at Agincourt (1415), over well-armed hosts, had proved the necessity of abandoning the military tactics hitherto in vogue, and which were founded upon the plan of the tournaments of that day. The discovery of gunpowder (1330), which was first practically employed for hand weapons in the fifteenth and sixteenth centuries, hastened the transition to a new system of tactics, and the invention of printing (1450), as well as the discovery of America, introduced a new era in which the traditions of the Middle Ages were for ever abandoned. Contemporaneously with this change the learned men of the Greek empire who were driven out by the conquest of Constantinople by the Turks (1453), introduced the study of the Greek language into Western Europe, and for the first time men began to read the great Greek writers in the original, whilst before that time their knowledge could be acquired only from defective Latin translations. In the year 1517 the Reformation began, and as it is interesting to know what Luther thought of gymnastics, I give the following extract: 'These two exercises and pastimes please me best, namely, music and knightly sports of fighting, wrestling, running, jumping, as bodily exercises, amongst which, the first banishes heart-care and melancholy thoughts, and the other

gives to the body free, agile, and strong members, and wonderfully preserves the health.'

In the second half of the sixteenth century there appeared for the first time a revival of the forgotten Greek gymnastics: viz. in the year 1569, in Venice, the book 'De Arte Gymnastica,' by Hieronymus Mercurialis, which was founded upon the most careful study of the Greek classics; and in the year 1590, the 'Agonisticon,' by Petrus Faber (Pierre du Faur) of Paris. Notwithstanding the importance of the appearance of these works, which were of value through their intimate connection with Greek gymnastics, they remained confined to the literary world, and had no direct influence upon the institution of a new and independent system of gymnastics.

The only kind of systematic gymnastics which was then practised was the art of fencing, the direct offspring of the tournaments (*l'escrime*). This art, which was of considerable importance in connection with the almost complete abandonment of armour, was most assiduously cultivated in Italy, and spread from thence into France, Germany, and England. The most celebrated fencing master was Salvator Fabri [1] in 1600, whose text-book of fencing was translated into all civilised languages and formed the foundation for all later developments of the art. Fabri occupied himself principally with the thrust, which he asserted to be by far the nobler and more masterly branch of the art; but he admitted that, on account of the conditions obtaining, that is, the weapons attainable or the armour of the antagonist, it might be desirable to substitute or add the cut. In the Roman states, however, the thrust was by-and-by almost exclusively practised, whilst in Germany both cut and thrust were eagerly studied. Thrust fencing was especially cultivated at Jena, where Wilhelm Kreussler founded the first fencing school in the year 1620. The Jena fencing school remained for a long time in the hands of this family, and only recently passed into that of the related Roux family. The great importance of the Kreussler school is shown by the fact that, in the beginning of the eighteenth century, some German cavaliers, who had studied in this school, attracted such

[1] *Des kunstreichen und weltberühmten Fechtmeisters Salvatoris Fabri Italienische Fechtkunst*, by Isaac Elzevier, in Leyden, 1619.

general attention by their exercises in Paris itself, that no one there was appointed a master of fencing until he had fought with one of these gentlemen and obtained from him a certificate of capability.

In Germany, and especially in the German universities, thrust fencing predominated everywhere in the seventeenth century; towards the end of the century it fell off considerably, and cut fencing took its place. In Jena, however, thrust fencing, after the old traditions, lasted longer, and even in the present century was diligently practised in duels, until it disappeared towards 1840 and gave way to cut fencing. At the present moment thrust is never practised in duels in Germany, but either cut fencing or shooting. In the Latin countries, especially in France, the rapier still plays a conspicuous *rôle* in the duel, although, it appears, not a very dangerous one. With other thrusting weapons too, such as poniards and lances, a systematic kind of fence gymnastics was taught, which, however, attained to very little importance. On the other hand, bayonet fighting was much more useful. The bayonet was first manufactured at Bayonne in 1640, and was already used in war in the Netherlands in 1647. The bayonet was, however, more generally employed in the eighteenth century, and by the end of this century had become a universal weapon. It was more especially used in attacks of masses against the enemy's columns when the men rushed forwards in a straight line, striking down whatever stood in their way. In a systematically drilled manner, for hand-to-hand encounters with the enemy's infantry or cavalry, however, bayonet fighting was only first carried out at the beginning of the present century, first of all in the Danish and Swedish armies (1806 and 1807). In the German army the Saxon State was the first to begin fighting with the bayonet in single combat, and since then the other German States, as well as Austria, have followed their example. Military exercises proper, such as tactical manœuvres for warlike purposes, were first introduced by Gustavus Adolphus, and later especially developed by Frederick the Great and Napoleon I.

In medicine, too, gymnastics met with an enthusiastic reception. The brilliant discovery of the circulation of the

blood by Harvey in 1619 had laid the foundation for the mechanical comprehension of the processes in the animal body. Building on this foundation, Borelli wrote his celebrated work, 'De Motu Animalium,' Rome 1680, in which he endeavoured to refer both involuntary and voluntary movements of animals to the mechanical laws prevailing in inanimate nature, and thus considerably enlarged the mechanical principles of biological processes. Thus the prevailing purely chemical schools receded gradually, and gave place to the *iatro*-mechanical school, which was disposed to refer the explanation of vital phenomena almost entirely to physical causes and only in a very small degree to chemistry. Sydenham (1624–1689), although not an *iatro*-mechanist proper, but rather more inclining to Hippocratism, was a great advocate of bodily movement as a means of cure; and upon his experience Fuller built further in his 'Medicina Gymnastica,' which was translated into German from the sixth edition in the year 1750.

Boerhaave (1715–1758), who entirely adhered to the doctrine of the *iatro*-physicists with reference to the comprehension of the organic processes, nevertheless adhered to therapeutics of the most purely chemical order. On the other hand, Friedrich Hoffmann (1660–1742), the first and most important representative of the mechanical system, in his work 'Representation of the Incomparable Advantages of Movement and Bodily Exercises, and the Manner of utilizing them for the Preservation of Health,' advocates most energetically active and passive movements as a means both for the preservation and restoration of health. In agreement with Hippocrates, Celsus, and Galen, he also strongly recommends friction, yet he adds, 'The physician must be careful in advising movements.'

Tissot, in Lausanne (1780), warmly recommends, from a medical point of view, medicinal gymnastics; these aimed at improving the general health of the sick and especially of scholars. He gave them advice how to improve their constitutions and preserve their health by walking, driving, riding, sailing, dancing and billiards, as well as instruction on other sanitary rules, such as regarded regularly ordered diet and a sufficiency of sleep. He adduces a number of examples, in

which weakly and diseased persons, by means of a regular movement cure and a carefully ordered diet, had very greatly improved their state of health and reached a great age. In particular he recommended water as a beverage ; wine, he urges, is too exciting, and consequently necessarily shortens life when it is used to excess. Tea, coffee, and tobacco are considered poisons by Tissot. 'We know that we are poisoning ourselves ; but the poison is sweet and we swallow it.' Cold baths, severe friction of the body, and the drinking of mineral waters are most strongly recommended; on the other hand, the regular use of powerful purgatives, especially also bleeding, are earnestly deprecated.

Johann Peter Frank, in his 'System of a Complete Medicinal Policy' (1780–1783), describes very fully the restitution of gymnastics and their employment in public education, but warns against excess : 'From carelessness or want of understanding too much may be done ; if, for instance, we attempt to produce strong athletes from weaklings.' And further on, in Book II. p. 630 : 'When I contemplate the condition of soldiers, especially among the French, how the body of the most clumsy peasant assumes, in the hands of an able corporal, without chastisement, even in the first year, quite a new bearing, and becomes agile and capable of taking part in all possible movements of the most complicated nature ; further, that it is noticeable in the soldier to the end of his life that he has been drilled in his youth, so that every action of the body carries its own recommendation ; it is impossible for me not to conclude that even students, under the instructions of an accomplished teacher of exercises, would lose much of that pedantic appearance which is not infrequently an obstacle to the practice of a useful science, and also that regular systematic exercise for a long period during youth would be calculated to induce in every scholar a profitable alternation of intellectual work with healthy bodily exercise.' Frank then describes the different kinds of gymnastic games and exercises with their respective advantages and disadvantages.

In the meantime, an essential change had taken place in scholastic gymnastics. The most prominent philosophers of the previous century had already specially insisted that bodily

and mental development should always be carried on at the same time in a growing youth.

Michel de Montaigne (1533–1592) thus expresses himself in the first edition of his Essays (1580), in the chapter 'De l'Institution des Enfants:' 'Il n'y a remède: qui veut faire d'un enfant un homme de bien, sans doute il ne le faut épargner en jeunesse; et faut souvent choquer les règles de la médecine: vitamque sub divo et trepidis agat in rebus (Horace, 'Carmina,' iii. 2). Ce n'est pas assez de lui roidir l'âme, il lui faut aussi roidir les muscles. . . . Les jeux mêmes et les exercices seront une bonne partie de l'étude; la course, la musique, la danse, la chasse, le maniement des chevaux et des armes. Je veux que la bienséance extérieure et la disposition de la personne se façonne quand et quand l'âme. Ce n'est pas une âme, ce n'est pas un corps, qu'on dresse; c'est un homme: il n'en faut pas faire deux; et, comme dit Platon, il ne faut pas les dresser l'un sans l'autre, mais les conduire également comme une couple de chevaux attelés au même timon; et, à l'ouïr, ne semble-t-il pas prêter plus de temps et plus de sollicitude aux exercices du corps et estimer, que l'esprit s'en exerce quand et quand et non au rebours? . . . Endurcissez-le à la sueur et au froid, au vent, au soleil, aux hasards qu'il lui faut mépriser. Otez lui toute mollesse et délicatesse au vêtir et coucher, au manger et au boire. Accoutumez-le à tout: que ce ne soit pas un bon garçon et dameret, mais un garçon vert et vigoureux. Enfant, homme, vieil, j'ai toujours cru et jugé de même.'

John Locke, too (1632–1704), lays great stress, in his 'Sensualistic Philosophy,' upon the bodily training of youth.

The greatest effect, however, was produced by J. J. Rousseau (1780), in his 'Emile, ou de l'Education,' Genève: 'Tous ceux qui ont réfléchi sur la manière de vivre des anciens attribuent aux exercices de la gymnastique cette vigueur de corps et d'âme qui les distingue le plus sensiblement des modernes. La manière dont Montaigne appuye ce sentiment montre qu'il en était fortement pénétré; il y revint sans cesse et de mille façons. En parlant de l'éducation d'un enfant: pour lui roidir l'âme il faut, dit-il, lui durcir les muscles; en l'accoutumant au travail on l'accoutume à la douleur; il le faut rompre à l'âpreté des exercices pour le dresser à l'âpreté

de la dislocation, de la colique et de tous les maux. Le sage Locke, le bon Rollin, le savant Fleuri, le pédant de Crousaz, si différents entre eux dans tout le reste, s'accordent tous en ce seul point, d'exercer beaucoup les corps des enfants. C'est le plus judicieux de leurs préceptes; c'est celui qui est et sera toujours le plus négligé. J'ai déjà suffisamment parlé de son importance, et comme on ne peut là dessus donner de meilleures raisons ni des règles plus sensées que celles qu'on trouve dans le livre de Locke, je me contenterai d'y renvoyer, après avoir pris la liberté d'ajouter quelques observations aux siennes.' The great influence which Rousseau exercised upon the system of education of his time soon led to a practical realisation of these ideas, only theoretical since the destruction of Greece; and there were three men, Basedow, Salzmann, and Pestalozzi, who were the most prominent in adapting them to daily life.

In the year 1774 Basedow founded an educational institution, or, as it was then called, a 'Philantropie,' at Dessau, and here arose the commencement of a new system of scholastic gymnastics. Salzmann was long employed at this institution, but left it after some years, and founded one of his own in Schnepfenthal. Gutsmuths entered this institution in the year 1785 as teacher, and found there already some beginnings of scholastic gymnastics. Gutsmuths (*b.* August 9, 1759; *d.* May 21, 1839) devoted his whole attention to these gymnastic efforts, and whilst he partly endeavoured to connect his teaching with the traditions of Greek gymnastics, and partly made independent advances of his own, there arose, in the course of seven years, a scholastic gymnastic system which Gutsmuths, in a special work, published in the year 1792 ('Gymnastics for Youth'). The definition of gymnastics which Gutsmuths gave, and in which we find his views very clearly expressed, was as follows: 'Gymnastics is a system of exercises which are calculated to produce endurance and strength, suppleness and beauty of the body.'

At the same time with Gutsmuths, another master in Dessau endeavoured, by historical research and practical effort, to establish a scholastic gymnastic. This was Keith, who recorded his experiences in the work 'Encyclopædia of Bodily Exercises,' the first volume of which appeared in the year 1793,

simultaneously with Gutsmuths' book. The second volume followed in 1795, and in 1818 there appeared the second complete edition of the work, which had grown to three volumes.

Pestalozzi (*d.* February 17, 1827) appears as the third teacher who warmly interested himself in the development of bodily exercises, and greatly promoted the development of scholastic gymnastics in his school at Ifferten, and published a book in 1807, 'Upon Bodily Development, an Introduction to an Elementary System of Gymnastics,' in which he demonstrates the necessity of bestowing the greatest attention upon the cultivation of the body equally with that of the mind.

By the united influences of these three authorities a scholastic gymnastic was developed in the beginning of this century, which, though not of large extent, nevertheless was a step in the right direction, and could boast itself of having successfully stood the test of practical utility.

In the meanwhile important political events had occurred which greatly interrupted the tranquil growth and extension of the scholastic gymnastic. From the convulsions of the French Revolution Napoleon had emerged as emperor, and after shaking all Europe by the immense extent of his wars, destroyed the military power of Prussia in 1806. In the times of foreign oppression which now prevailed in Germany, the Berlin gymnastic teacher, Friedrich Ludwig Jahn (*b.* August 11, 1778; *d.* October 15, 1852), devised the plan of rescuing youths from the weakening effects of a life of luxury by means of energetic scholastic gymnastics, and the raising of them to such a degree of strength and energy that later on they might be in a condition to throw off the yoke of foreign power. In the year 1810 he published his ideas in the work 'Deutsches Volksthum,' and in the following year he opened the first gymnasium in the Hasenhaide, near Berlin. In partnership with Friesen, Eiselen, and Massmann, Jahn formed a gymnastic after his own ideas, which had for its aim not only to be a sufficient counterpoise against a sedentary mode of life and the mental strain of school, but which should also produce the greatest possible degree of bodily strength and suppleness, coupled with firmness and intrepidity of spirit, for these

qualities alone he considered answered to his aim of rendering the youth capable of fighting and increasing their bodily and mental power of endurance. In accordance with his endeavour to banish all foreign words from the German language, and to replace them by words of German origin, he called his gymnasium 'turn.' He justifies the use of this word in the following manner: 'Turnen' is a primitive Teutonic word which is also to be found in many German sister tongues, and always means a powerful turning, swinging, stirring, and moving; 'A *turner* in old times was a young soldier, a good wrestler, a pleasant fellow, a lively young *blade*, who practised himself well in all knightly deeds, whence "turnieren" and "turnier" took their name and origin.' Thus a meaning was given from the beginning to the word in the sense of a lively and active but slightly regulated movement, and this acceptation of the word persisted according to the meaning given to it by Jahn.

During the years 1813 to 1815 the gymnastic activity of the Turnplatz in the Hasenhaide was interrupted by war. Teachers and scholars entered the army, and by preference joined the Lützow Volunteer corps. Friesen fell on the field of battle. Jahn returned in 1815, and again undertook the superintendence of the Turnplatz, which Eiselen had conducted during his absence. In conjunction with the latter, Jahn published, in the year 1816, 'Die Deutsche Turnkunst.' Very soon gymnastics spread from Berlin all over Germany, and were everywhere enthusiastically greeted and energetically practised, as well by the young as by those of riper years. Soon, however, political events placed obstacles to the development of gymnastics. The Wartburg festival of German Burschenschaft in the year 1817, and the murder of Kotzebue by Sand afterwards, called down repressive laws from the alarmed governments, which were also partly directed against gymnastics. Jahn himself was suspected of being concerned in revolutionary intrigues and was arrested, and on January 2, 1820, several gymnasia in Prussia and the neighbouring states were closed. Later on Jahn was released and came back to Freiburg, but exercised no further influence upon the development of gymnastics up to his death in 1852.

Nevertheless, the idea of improving the bodily development of growing youths, especially in the higher schools, by means of gymnastics, did not die out. Divested of its political character, it was carried on with enthusiasm by Eiselen in Berlin, Massmann in Munich, Klumpp in Stuttgart, Ravenstein in Frankfort, Werner in Dresden, and others, notwithstanding much opposition.

In the year 1836 a small treatise was published in Berlin by the medical counsellor Dr. Lorinser ('Upon the Preservation of Health in Schools'), in which the author earnestly recommended, from a medical and scientific point of view, the re-introduction of scholastic gymnastics; and on June 18, 1842, Eiselen was enabled to open a new gymnasium in Alt-Moabite, after which, in the year 1844, Massmann, being summoned to Berlin, established a gymnasium in the Hasenhaide, but not the one formerly used by Jahn.

At this time there appeared a man who exercised a considerable influence upon the development of German gymnastics. This was Adolf Spiess (*b.* February 3, 1810; *d.* May 9, 1858) who was appointed teacher of history, singing, and gymnastics in the school at Burgdorf, in Switzerland. The influence of Spiess was most remarkable in this way, that the exercises were much quieter and more regular than they had been under Jahn, and consequently were not pushed to the utmost verge of capability. With Spiess, gymnastics were no longer a preparation for combat with a powerful enemy. In his opinion, it was a question of how best to carry on a system of carefully regulated movements, so as to produce a durable development of the body during youth, within the bounds of health and gracefulness. This object Spiess attained chiefly by two innovations: in the first place he introduced free exercises, in which a great number of scholars could make certain directed movements at the teacher's command, the performance of which did not generally require any great strength, but for which regularity of all the performers, precision, and erect carriage were the principal conditions. In the second place he changed the exercises from open to closed gymnasia. Although the advantages of fresh air were lost by this alteration, yet the loss was compensated for by a considerable gain in the regularity of the

instruction, which was no longer disturbed by unfavourable weather, and by the much higher degree of precision thus attainable, so that discipline and superintendence were found to be much more effectual in the closed hall than they had been in the open air.

With these two modifications German gymnastics have not only continued but have considerably developed. From the higher schools they have spread to the national schools, and in the last ten years have reached from boys' to girls' schools. Not only has gymnastic instruction become an integral part of all teaching in Germany, but also by means of these gymnasia, formed by voluntary association, the exercises are continued up to middle age. Gymnastics have spread even far beyond the confines of Germany. In all countries, in all quarters of the world, wherever Germans collect in any great number, so certainly there is founded a choral union and a 'Turnverein'; and the 'Turn-halle' serves for the common assembling place, not only for bodily exercises but also for all festivals of a national character. Among none of the modern nations have gymnastics attained such a development and such an importance as amongst the Germans, and it may be said with truth that the Germans are only second to the Greeks in their development of national gymnastics.

In France some attempts have been made since 1817, from the influence of the German gymnastic movement, to introduce scholastic gymnastics. These, however, have led to no great result. In the year 1820, Colonel Amoros, who had until then been conducting a gymnastic institution in Madrid, came to Paris, and by his own efforts, seconded by the support of the Government and some private persons interested in the matter, he succeeded in founding the first French gymnastic establishment. The exercises which Amoros introduced consisted in marching and evolutions, different kinds of running, wrestling, leaping, climbing, exercises with the dynamometer, &c. By means of the accompaniment of song, order and rhythm were introduced into the mass exercises, and by prizes, which were awarded by jury chosen from amongst the pupils who had most distinguished themselves, their zeal and ambition were stimulated. These

gymnastics were described by Londe in his 'Gymnastique Médicale,' which appeared in the year 1820.

Starting upon this foundation Delpech, a few years after, introduced gymnastics into his orthopædic institution in Montpellier as an essential orthopædic means of cure. He was, undoubtedly, the first physician who employed gymnastics in an extensive way for orthopædic purposes, especially for the treatment of skoliosis; for although the true founder of orthopædics, Venel, in Switzerland (Orbe, Canton de Vaud), had already, at the end of the former century, used numerous passive movements for orthopædic purposes, particularly for the treatment of club-foot, Delpech rather dealt with a thorough gymnastic system, consisting of active movements, and having for its aim the strengthening of the whole body. For skoliosis in particular, which had been hitherto treated exclusively by means of extension beds and corsets, the introduction of gymnastics was a very valuable novelty, and although the system advised by Delpech himself, inefficient in many particulars, underwent very essential modifications in the course of time, nevertheless the principle that skoliosis demands, besides treatment with stretching and pressing apparatus, gymnastic treatment which shall counteract the evils attendant to a greater or less degree upon all mechanical appliances, has been recognised and acted upon by all intelligent orthopædists of a later date.[1]

The gymnastic movement set on foot by Amoros did not, however, develop further. It gradually decayed, and only since the last war have attempts been made to reintroduce scholastic gymnastics in France, and these appear to have been attended with but small results.

In England neither pedagogic nor medicinal gymnastics have been much developed. In this country bodily development is favoured by sports, which begin in the early years of youth by active recreations, including walking, running, rowing, driving, riding, and quite recently cycling, and fencing and a special scholastic gymnastic is to a great extent superfluous.

[1] This excellent principle is seldom carried into effect, and when exercises are judiciously employed, mechanical help is frequently discarded. When mechanical apparatus is used it too frequently, if not invariably, consists of heavy and complicated machines, which interfere with instead of encouraging muscular movement.—N. S.

In Sweden, however, a peculiar form of gymnastics was originated, which, because it appeared especially useful as a curative measure, is generally known in Germany under the name of the Swedish gymnastic cure. The founder of this gymnastic system was Pehr Henrik Ling (*b.* November 15, 1776). After leaving the gymnasium, Ling studied theology in Upsala, left this university in the year 1797 after a failure in the theological examination, and travelled through a considerable portion of Europe. At Copenhagen he learnt the art of fencing from two French emigrants, and speedily acquired great proficiency in this accomplishment. In the year 1805 he went to the Swedish university of Lund and offered himself as teacher of fencing and modern languages. At the same time he gave lectures upon Scandinavian mythology. In the course of the same year he received the appointment of fencing master in the university and commenced the formation of a gymnastic system which was characterised by the greatest simplicity of every movement, for he believed that in this way only could he bestow the necessary attention to its working. In the year 1812 he petitioned the Swedish Government to be allowed to found a gymnastic institution in Stockholm at the expense of the state, and received the following reply from the Minister: 'We have jugglers and rope-dancers enough without taxing the state coffers on their behalf.' Ling was not, however, discouraged by this answer; he settled down at Stockholm in the year 1813, and then received permission to form a gymnastic institution, although but a moderately endowed one. In this institution Ling worked for a series of years under somewhat adverse circumstances, but he succeeded in obtaining, in the year 1834, a very considerable increase to the building and yearly income. Ling also employed himself as an epic poet, and on account of his poems in Scandinavian mythological subjects was made an Associate of the Swedish Academy.

Ling died in the year 1839, at the age of sixty-three, of tuberculosis of the lungs and liver. His successor as principal of the Central Gymnastic Institution in Stockholm was Branting (*b.* 1799), who, on account of his delicate health, had placed himself under Ling's gymnastic cure in the year 1814, and had

been thereby made quite strong. The institution remained under Branting's supervision until his death in 1881.

A number of Ling's pupils travelled into different countries. Georgii went to Paris, and there opened his Kinésothérapie in the year 1847; Dr. Rou went to St. Petersburg; Dr. Roth to London; and these men founded institutions in which, for the most part, *cure gymnastics* were practised. I know nothing of the further fate of these institutions.

It is very difficult to criticise Swedish gymnastics. There lie before us, composed by Ling himself, 'Reglemente för Gymnastik, 1836,' and 'Reglemente för Bajonett fäktning, 1838,' both written for the Swedish army. A larger work, 'Gymnastikens allmäna grunder,' remained unfinished, and was only published after Ling's death, in 1840, by his pupils Liedbech and Georgii, and translated by Massmann in 1847. In this work Ling declares life to consist of the blending together of three elements—the dynamic, the chemical, and the mechanical—which through their opposite action produce variety in vital phenomena. As soon as one of these elements is deficient or diseased, a means of cure belonging to the same category should be chosen, either to restore the balance or the healthy condition. The means of cure for the mechanical element is gymnastics. According to the object to be attained, Ling divides gymnastics into the scholastic, medicinal, and æsthetic. The forms of movement which are to be employed are the active, the passive, and compound. In this last consists the principal peculiarity of Ling's system. The active movement is performed exclusively by the will of the individual exercising. In the passive movement, a second person, the gymnast, conducts the movements of the body of the patient or pupil, who neither assists nor opposes. In the compound movements an alternate influence is exerted by both patient and gymnast, for either the patient performs a movement to which the gymnast opposes an equal resistance, in such a manner, however, that he does not completely hinder this movement but only renders necessary a greater degree of power to effect it (compound concentric movement), or the gymnast conducts the movement of the patient's limbs while the patient opposes a resistance in accordance with his strength (compound eccentric movement).

Gymnast and patient thus alternately operate, in the first case the patient, and in the last the gymnast, gaining the ascendancy in turns. A special direction is, that the movement as well as the resistance should uniformly commence and subside gradually, so that no sudden, violent, or tremulous movement from excesive effort should occur.

Every gymnastic lesson should begin with the mildest movements and increase to stronger ones, and finally towards the end of the lesson they should again decline. This regulated co-operation of two persons for the purpose of certain movements was in fact an essential and novel principle of Ling's gymnastics, and however much it deranged the scholastic gymnastics, by heavily fettering the freedom of the pupil, and thus depriving him of much of the pleasure of the work, so much the more favourable did it prove in medicinal gymnastics, in affording a precision and a graduation of the desired movements that were not possible with either the purely active or the purely passive movements. This principle of combining to a certain extent gymnast and patient as one person, whether for aiding or resisting, has remained unaltered in medical gymnastics; but of the other portions of Ling's system, especially the three typical forms (the mechanical, chemical, and dynamic), as well as (after the crudest natural philosophy) supposed interchangeable action, every trace has long since disappeared. It was also an error of Ling's to ascribe to every single muscular movement a special effect upon the general health; as, for example, when he believed that an arm movement while standing had quite a different effect from an arm movement while lying or sitting.

Upon this assumption an extremely complicated system of gymnastics was formed which sharply differentiated the movements necessary in various cases. Thence arose the necessity for a considerable number of assistants, for four people might be required to hold the patient in a certain position, while the fifth, the gymnast proper, conducted the desired movement. Now it must be admitted that all movements are not equivalent in their action upon the body; for example, an arm movement may produce a different result from a movement of the leg, and therefore, in cases which are to be treated in this way the

choice of the appropriate movements (the gymnastic prescription, as the Swedish gymnasts called it) demands considerable knowledge and experience. Nevertheless, a wide road is thus opened for subtleties into which Ling and his pupils themselves fell in reference to the selection of the necessary movements. For example, Ling prescribes for gravel 'graduated rubbing movements upon the groin and perineum, and cross angular movements directed obliquely towards the side, where the pain in the kidney is felt, together with strong perineal rubbings combined with forward *angular* movements, and his pupils and followers developed this elaborate process still further.

From an orthopædic point of view, Ling's gymnastics corresponded closely with the so-called antagonistic theory—*i.e.* the theory which ascribes all deformities to the unequal action of muscles acting antagonistically upon any part of the body.

Upon this supposition there was a great temptation to the use of a powerful localised gymnastic exercise, which only took into consideration and strengthened the weakened antagonists, whilst the too powerful muscles were allowed to remain at rest. The antagonistic theory, however, has lately met with great limitations, and in those cases where it is still applied it is used not for weakened but for paralysed groups of muscles which it is proposed to restore to action. This result may be effected in appropriate cases by means of electricity, but not by the patient's will, from which the power to move the muscles is entirely withdrawn.

In Germany, Swedish gymnastics became more especially known from the exertions of Rothstein and Neumann. Hugo Rothstein (*b.* August 28, 1810) was an artillery officer in the Prussian army, and was sent by the Minister of War, Von Boyen, in the year 1845, to Stockholm, at the expense of the State, to acquire more intimate knowledge of Ling's gymnastics and to go through a course in the Central Institute. For this purpose Rothstein resided a year in Stockholm, and after that two months in Copenhagen, in order to learn the kind of gymnastics practised in Denmark, and returned to Berlin in the middle of the year 1846. Here he published the information obtained in Sweden in the work entitled 'Gymnastics or the System of the Swedish Gymnasiarch P. H. Ling, Berlin,

1847 to 1857.' In 1848 he assumed the superintendence of the newly founded Military Central Gymnastic Institution in Berlin, and retained this post until his death in 1863.

A. C. Neumann was a practising physician in Graudenz, where he established an institution upon the principles of Swedish gymnastics. He also had been in Stockholm, commissioned by the Prussian Government to perfect himself in the study of these gymnastics. In the middle of the year 1850 Neumann came to Berlin, occupied himself there with orthopædic gymnastics, and together with Rothstein published 'The Athenæum for Rational Gymnastics,' a journal which began in 1854 and came to an end in 1857 with its fourth volume. Neumann died soon after. Eulenberg also visited Stockholm in the beginning of the year 1850 to learn Swedish gymnastics, and he afterwards established an institution for Swedish medical gymnastics and orthopædics in Berlin, which he conducted until 1879. In this institution gymnastics were (at least in later years) exclusively used for orthopædic purposes. Quite lately Dr. Gustav Zander has introduced in Stockholm an alteration in gymnastics, consisting in the employment of very ingeniously constructed machines in place of the hand of a gymnast, which machines not only accomplish passive movements in the body of the patient, but also furnish the required resistance in the combined active movements. Zander's method of machine gymnastics has been approved and adopted in various other towns of Sweden and Russia besides Stockholm, but, as far as is known to myself, has obtained no firm footing in Germany, England, or France.[1]

Massage.

Since 1870 or thereabouts, massage has received considerable attention in almost every European country, and particularly in

[1] A Zander Gymnasium was opened in London a few years ago, and has been highly approved of by the medical profession. The machines were obtained from Stockholm, and are exactly similar to those used by Dr. Zander. This institution is most valuable for the treatment of a great variety of cases, and is an excellent substitute for Ling's system of gymnastics, whilst the management is so conducted that it is free from that empiricism, or, to say the least, extravagant and costly enthusiasm with which the 'movement cure' is so often surrounded.—N. S.

Germany. The word 'massage' is derived, according to Piorry, from μασσειν = to rub; according to Savary, however, from the Arabic word '*mass*,' to press softly. Those who are employed in the performance of these manipulations are called, in France, 'masseurs' or 'rebouteurs,' or 'rhabelleurs,' and when they are women, 'dames blanches.' The English expressions for the process are 'rubbing,' 'shampooing,' and a somewhat allied term, 'bone-setting.' The art of performing these manipulations now embraced under the term 'massage' is a very ancient one, and belongs undoubtedly to the earliest efforts which were made in the art of healing. The Chinese manuscript Kong-Fau, which is dated 3000 years B.C., seems to have contained detailed accounts of these operations. Similar in their nature are the *surchuna* of the Persians, the *ἀνατριψις* of the Greeks, and the *frictio* of the Romans, of which latter Martial sings:

> Percurrit agili corpus arte tractatrix
> Manumque doctam spargit omnibus membris.

It is precisely these movements belonging to massage which were developed into a special cure and applied preferentially by the Swedish medical gymnasts. They consist of rubbings, kneadings, pressings, strikings, choppings, sawing movements, slappings, shakings, &c.; all of them being movements in which the patient remains perfectly passive, but which are distinguished from the properly so-called passive movements in that they are not confined to the mechanism of a joint alone, but, without any reference thereto, operate directly either upon the soft parts or the bones. The too great importance attached at present to massage is due, however, not to the direct influence of Swedish gymnastics, but originates in France, and it has found in Dr. J. Mezger, of Amsterdam, an exceptionally expert advocate. Incited by his success, Professor Mosengeil[1] published a detailed description of the manipulations which are performed in this process. These latter are divided into four classes: *effleurage*, *massage à friction*, *pétrissage*, and *tapottement*. The parts of the body to be massaged must be so situated as to be within reach of manual operation;

[1] *Verhandlungen d. Deutsch. Gesellsch. f. Chirurgie.* 4. Congress. Berlin, 1876.

a deeply seated part, such as the hip-joint for instance, cannot be effectually massaged.

The part must be first washed with cold water, then the 'masseur' anoints his hands with any substance that facilitates their gliding easily over the surface of the skin.

Such substances are: olive oil, animal fat, especially in the form of the universally known cold cream, vaseline, black soap, or a special liniment, which is more often used in France, and which consists of—

Camphor . . .	10 parts
Laudanum . . .	10 ,,
Oil	60 ,,

If the part to be operated upon be very hairy it must be shaved, otherwise even with mild massage severe pains and possibly inflammation may ensue.

The rubber begins with *effleurage*—*i.e.* with centripetal strokes which are conducted with the full surface of each hand alternately over the desired part of the body. The strokings, at first slight, are gradually increased to a considerable strength and then gradually diminished. If the part to be operated upon is too small to permit the use of the whole hand, only the tips of the fingers are employed. By means of these strokings, abnormal collections of fluid, such as extravasations of blood or exudations, spread over a larger expanse which is favourable to their more rapid absorption, or else they are pressed inwards directly into the lymphatic vessels and thus driven away from the diseased parts. Stroking towards the periphery should only be performed in exceptional cases, because they act in an opposite direction to the lymph stream, but in the case of considerable fluid collections they have at times this advantage, that they procure towards the periphery a greater surface for absorption. Nevertheless, one must not subject every inflammatory swelling to *effleurage*, since an exudation charged with infectious matters may easily produce inflammation and suppuration in the neighbouring parts by its extension. Massage is entirely out of the question in all cases of venous inflammation, since by its employment detached pieces of thrombus or softened masses of detritus might be conveyed into the circulation, where they would produce the most serious disturbances. Soft tissue

growths, especially such as the well-known fungous granulations, may be crushed by *effleurage*, and thus their absorption rendered more easy. After the rubbing has been continued for a long time the skin reddens, the patient experiences a decided feeling of warmth, and sometimes the temperature of the part is raised, as may be shown by the use of a thermometer, a condition which only disappears gradually after the lapse of some hours. In many cases the pain produced at the commencement of the massage is very considerable, but by gradual increase in the strength with which the movements are performed the sensibility gradually declines. In the *massage à friction* the finger-tips of one hand work with energetic elliptical rubbings proceeding from the periphery towards the centre, whilst the finger-tips of the other hand follow with a stroking movement.

The parts which the fingers of the first hand press and pound the fingers of the other hand rub over afterwards with a circular movement. A considerable degree of dexterity and practice is necessary to perform this operation properly, as the fingers of each hand have to be moved differently. This is especially difficult when the left hand does the rubbings while the right follows with a stroking movement. *Pétrissage* is a thorough kneading of the parts. A fold of the affected tissues (the skin and especially the muscles) is raised between the thumb and the four other fingers of each hand, and whilst this fold is strongly pressed, both hands work together in an opposite direction to the longitudinal axis of the limb, and act thus slowly towards the centre of the body.

Tapottement consists in small blows which are bestowed upon the affected part either by the relaxed finger or by a special hammering apparatus made of indiarubber, wood, or whalebone.

Besides these there are the chopping and sawing movements, which are performed with the ulnar edge of the hand, and the slappings with the entire hand.

After this short sketch of the historical development of the different kinds of gymnastics, the question arises, 'What

Remedial use can be made of any of the above described forms of gymnastics ?'

According to an old proverb, 'Movement is life, and the cessation of movement, death.' This proverb is certainly not perfectly true, for we know many forms of vegetable and animal life which exhibit no perceptible movement. The most necessary element of life is more probably irritability—*i.e.* the power of reacting to extraneous influences in a more comprehensive manner than is possible to inanimate bodies.

Amongst these reactions, however, motion is one of the most essential, and is never absent from animal life. An animal body which is no longer in a condition to respond to certain influences of the outer world by movement has lost the essential property of life and has arrived at its antithesis, death. Disregarding the large sub-kingdom of invertebrate animals, we find in the vertebrates that the movements most necessary to life are the heart's action, and as a consequence the circulation of the blood and the expanding and contracting of the thorax with its consequence, (the gaseous exchange of the blood), the respiration. In the lower vertebrates both these movements may cease for a considerable time without necessary extinction of life.

Fishes and amphibia may be frozen in ice for many days, and possibly even weeks and months, to such an extent that the tissues of the body and blood itself are solidified, with the necessary consequence of the cessation of all movement, and after slow thawing respiration and circulation, as well as, later on, voluntary movement, may be restored and the animals therewith be restored to life. Reptiles, also, may remain for a long time in a motionless condition without being necessarily dead. When in the tropics the sun is drying up the marshy and boggy places, the alligators bury themselves deep in the earth and remain there in a motionless condition of rigidity, in which nevertheless circulation and respiration possibly continue in a very restricted manner, until in the rainy season the returning moisture restores them to movement. The only examples of this in warm-blooded animals is the hybernation of some of the lower mammalia, during which process voluntary movement entirely ceases; respiration and

circulation however continue, though in a much slower manner than at other times, and preserve that form of life which has been designated by the ancients as *vita minima.* In most mammals, and especially in man, such a condition does not occur. Here the total cessation of voluntary movement, and the consequent fall of temperature, necessarily causes death after a certain time. Interruption of *both* of the two acts most necessary to the maintenance of life—viz. respiration and circulation—induces death in a few minutes.

The movements producing respiration and circulation are only very slightly subject to our will. The strongest will cannot influence the beating of the heart, and even though we are able to voluntarily produce considerable alteration in the frequency and depth of the breathings, nevertheless the type of respiration which is most favourable to the conditions of the body at the time soon re-establishes itself, and thus is not only withdrawn from the influence of the will, but generally also from the consciousness. We are, however, able to influence in a very marked manner not only the respiration but also the circulation, by the voluntary movements of our muscular system. Increased voluntary movement leads after a short time to an increase in the heart-beats, as well as to an increased frequency and depth of the respirations. The consequences are a more rapid movement of the blood through the vessels of both the greater and lesser circulations, increased intake of oxygen and output of carbonic acid from the capillaries of the lungs, as well as the reverse of this process in the capillaries of the greater circulation, an increased evaporation of water from the skin and lung surface, a greater feeling of hunger and thirst, and after satisfaction of these, a more rapid transition of the ingested food into the juices of the body. Whether voluntary movements produce increased destruction of albumen and a correspondingly increased excretion of urea, is one of the most warmly contested points in the physiology of tissue metamorphosis.

According to Hermann Oppenheim's[1] book, the difference in the views of authors appears to result from the fact that

[1] *Beiträge z. Physiol. u. Pathol. der Harnstoff-Ausscheidung.* Pflüger's *Arch. f. d. ges. Physiol.* Bd. 23. 1880.

increased voluntary movement only produces an increase in the separation of urea when the movement is so violent as to give rise to a considerable degree of dyspnœa. The insufficiently nourished albuminous substance of the muscles, in consequence of the deficient supply of oxygen, is partly destroyed. In the *parenchymatous juices* its transition is completed into urea, as which it is discharged from the body through the kidneys. On the other hand, if the muscular movement is concluded in so tranquil a manner that no considerable degree of dyspnœa is produced, although the whole amount of the work may be very great, the albuminous substance of the muscles does not split up, the separation of urea is not increased, and the muscles appear to carry on their work exclusively by oxidation of carbohydrates, the final results of which, carbonic acid and water, are excreted by the lungs.

Voluntary movement, however, affects the circulation not only by increasing the action of the heart but also by acting directly on the latter by increasing the venous flow. Braune's [1] investigations have proved that the fascia in the region of Poupart's ligament is so arranged that the movements in the hip joint act by suction upon the blood contained in the crural vein and thus hasten its passage into the inferior vena cava. A similar suction apparatus of the muscles and fascia is found at the upper extremity under the clavicle,[2] but this is far inferior to the former in force and functional capacity. Much more important than even both of the above is the powerful suction which the *negative* pressure in the thorax, in inspiration, exerts on the returning venous blood, and the efficiency of which is considerably increased by greater frequency and depth of the respirations. The lymph current also is essentially quickened by this mechanical aspiration. The peristaltic movements of the intestine, as well as the secretory activity of the glands generally, are increased by movement.

Besides these general effects of voluntary movement, alterations are produced in the organs of motion themselves. The

[1] Braune, *Die Oberschenkelvene in anatomischer und klinischer Beziehung.* Leipzig, 1873.

[2] Herzog, *Beiträge zum Mechanismus der Blutbewegung an der oberen Thoraxapertur beim Menschen. Deutsch. Zeitschr. f. Chir.* vol. xvi. p. 1, 1881.

frequently exercised muscles increase in size, their colour becomes a brighter red, their fibres become firmer and thicker, and corresponding to these changes their power increases and they contract with greater rapidity and strength. These alterations in the muscles react upon the passive organs of movement. The bones become firmer and thicker, the prominences of the bones to which the muscles are attached become stronger and more defined, the tendons not only in their substance but in their attachment to the bones become firmer and more capable of resistance, the range of motion of the joints is increased, and the power of control in any desired position of the joints is improved. The equilibrium is thereby more safely preserved even in positions with a narrower support beneath the centre of gravity, and the whole bearing of the body and movement become more elastic and energetic.

These favourable effects of muscular activity occur only under certain conditions. The first is, that the body be richly and abundantly nourished, so as to be able to replace the increased loss of bodily substance. If this condition be wanting, the effect of movement upon the body is not strengthening but weakening. The composition of the nourishment must also correspond with the necessary requirements. We, no doubt, frequently find that different men are able to develop great bodily strength from very different nourishment; for example, one will take only vegetable, another only animal, a third, mixed food, &c.; and the choice as well as the relative advantages of the food are essentially influenced by the effect of climate. Nevertheless it is probable that, under certain external conditions, there is a particular kind of diet in each case which is best fitted to raise to the highest condition the mechanical activity of the organs of movement. The Greeks, from the high estimation in which they held the display of athletic power in their sacred games, empirically discovered this fact, and therefore appointed a particular diet (*ἀναγκοφαγία*) as a necessary requisite of the athletic vocation.

The second condition necessary for a favourable effect upon the whole body from increased muscular movement is, that the exercise should not be continued to the extreme degree of exhaustion. Strenuous bodily movements make such great

demands not only upon those organs of movement which are immediately involved, but also indirectly upon the heart and lungs, that the functional capacities of these organs may be easily overtaxed, and great and permanent injuries may ensue. It is well known that in many of the unwounded soldiers returning from the Franco-Prussian war hypertrophy of the heart, together with irregularity of the pulse, and eventually also loss of albumen through the urine, were caused by the enormous fatigues of marching. It is also known that in moments of great athletic efforts hæmoptyses not seldom occur, often succeeded by phthisis running a rapid course. Further, it has been proved that a great many professional athletes are affected by progressive muscular atrophy, and hernia is of very common occurrence among acrobats. Moreover, fractures and dislocations may happen, especially fracture of the patella and of the olecranon, from muscular strain, and the conjecture may be justified, though I am not able to support it by statistical proof, that movements continued so long as to cause embarrassed breathing and exhaustion must be regarded as more likely to shorten than to lengthen life.

After the enumeration of these evils it may naturally be asked, 'What useful purpose do such exercises serve?' If the object be a military one, it cannot be a matter of consideration whether a portion of the troops is unable to sustain these efforts, for even if half the battalion lies exhausted on the road from the fatigues of the march, yet the other half, appearing at the right time in the right place, may be of such importance to the decision of the battle that the performance of the march may nevertheless be regarded as having been necessary.

Such occurrences may be regretted, but one must expect them; they belong to the dangers of war, and that army which is the most capable of enduring such fatigues is on that account the superior. Just as little can it be taken into consideration to what dangers the professional acrobat or athlete is exposed. By this occupation he earns his living and must accept the dangers belonging to it just like a slater, a stone quarrier, a quicksilver worker, &c. But conditions in medicinal and scholastic gymnastics are quite different. Here the aim is not of the above kind, in regard to which the dangers connected

therewith are a matter of indifference; here gymnastics have the object either to cure bodily suffering, or to harmonise the bodily conditions innate in each person in the manner most conformable to health and beauty. Here the demand on the individual must not exceed his capacity, but I am not specially anxious, as regards scholastic gymnastics, to reproach them for the accidents which may occur, for—

Nil prodest quod non lædere possit idem.

Scholastic gymnastics have always had a great attraction for boys, and nothing is more dangerous than excessive anxiety and restraint. However, particular care must be taken to ensure that each individual pupil undertakes no more than he can easily perform, and to oppose most energetically any excess in the performance of acrobatic or athletic feats. These restrictions were not especially observed in the original gymnasium of Jahn. I do not make this statement by way of reproach, for Jahn was actuated by a high motive which threw such considerations into the background. His object was the *arming* and rejuvenation of the nation for the conquest of the French usurpers; but for more peaceful times his system of scholastic gymnastics is too severe, and accompanied by unnecessary dangers. The modifications which were introduced by Spiess removed these objectionable qualities.

English sports are not in respect to this subject unworthy of consideration. The most essential feature of sports is that a number of men compete with their utmost strength to succeed by the exhibition of the greatest activity. Emulation here urges competitors to efforts which not infrequently entail permanent injury, whilst the object sought is not of such a nature as to make one disregard these injuries. Whether statistical information on this point exists I am not aware, but it is well known that the celebrated surgeon Liston died from the rupture of an aneurism of the aorta, which had been produced by overstrain in rowing; and such cases cannot be infrequent.

Medical gymnastics, which are directly employed to combat existing maladies, have naturally to respect the Hippocratic maxim, *μὴ βλάπτειν* (*non nocere*), much more carefully than

the scholastic, and on that account must embrace very much more prudent forms of movement.

The first form of medical gymnastics is the dietetic; but however important this may be from a medical point of view, there is not very much to be said upon the subject, which has not been long known to the general public. The most simple form of it is walking, in which the bodily movement is almost exclusively confined to the lower extremities. The respiration of fresh air, increased by the movement, assists most essentially in its good effect. Much more energetic is riding, in which the quick motion of the body through the air and the shaking from the pace of the horse, with the active efforts of the muscles, which are necessary not only for the firmness of the seat but also for the preservation of the equilibrium, combine to form a species of movement which can be rivalled by no other in its utility. Next to this comes riding on a velocipede, which must be suitable to many, in that a velocipede costs less than a horse, requires neither food nor attendance, and also that the person riding upon it does not run the danger of considerable injury from a fall.[1] This kind of gymnastics, which has been greatly pursued in France and England, is now beginning to become popular in Germany, and especially in Berlin, with the beautiful two-wheeled velocipedes with the large forewheel, the edge of which is covered with an indiarubber tire to modify shock. Velocipede riding has, however, the inconvenience that one is obliged at every considerable rise or fall of the road to dismount and walk.

Gymnastics with 'bar bells' are also well known. By means of their weight they exercise the muscles of the upper extremities, and by transference through the shoulder girdle they influence the muscles of the thorax, which act for the most part as respiratory muscles, thus inducing more energetic action than simple movements of the arms alone. Whoever wishes to obtain more precise information about gymnastics with 'bar-bells' will find it in Schreber's 'Chamber Gymnastics.'

A very much improved kind of bar-bell has been introduced

[1] This statement does not accord with my experience, as I have met with many cases of severe injury resulting from such accidents.—N. S.

by L. Seeger[1] in the form of his *kugelstab*. This is, in effect, a bar bell with a very much elongated middle piece, from which the iron balls serving as weights can be removed, or to which they can be fastened by screws in different positions. The manner in which the use of the *kugelstab* differs from that of the bar-bell is, that both hands grasp the one instrument simultaneously, and that therefore the arms are placed in firm connection with one another, which gives a great advantage in many movements, particularly in flexions, twisting and turning the upper part of the body. Drill gymnastics, particularly slow military step to counting, is of great importance to the bearing of the whole body as well as for the formation of a firm even step, only it is desirable that the gymnastic teacher should possess an authority over his scholars approaching that of military discipline, which considerably increases the effect; otherwise the exercise will be wanting in the requisite earnestness. The different kinds of fighting with the sword, the sabre, the foil, and the bayonet may be used as dietetic gymnastics; and they have this advantage over the other forms, that they maintain the interest of the pupil, who must be ever ready to parry his opponent's attack and to make his own. Rowing, when undertaken in moderation, is also a good gymnastic exercise. Swimming combines in the happiest manner muscular activity with the refreshing excitation of cold water and the lightening of the weight of the body, owing to the fact of the latter being in a medium of almost the same specific gravity as itself.

Leaving now the subject of dietetic gymnastics where it is simply a question of preserving the body in health, or combating slight ailments, and coming to medical gymnastics proper, we find the principal domain of the latter is orthopædics. In order to estimate the value of gymnastics from an orthopædic point of view, we must briefly consider the maladies hereto belonging and their causes.

ORTHOPÆDICS, taken in its widest sense, is the description of the nature of the deformities of the human body, and also

[1] L. Seeger, *Diätetische und ärztliche Zimmergymnastik.* Wien, 1878.

the means of redressing them. Upon investigating the causes which produce deformities we find them to be principally two: in the first place weight, and in the second the effects of traction or pressure. These are generally situated in the body of the deformed person, occasionally they may be imparted to it from without. Besides this, both factors may be combined, and, in fact, are so very frequently. With congenital deformities there is a third cause, essentially unknown to us, namely, defective formation. These are undoubtedly caused by mechanical conditions, the nature of which is, however, so complicated, that it is only in very few cases that investigations have enabled us to gain an insight into them. Such congenital deformities are, for example, the inward turning of the foot, in consequence of defect of the tibia; abnormal position of the hand, in consequence of defect of the bones of the forearm; deformity of the knee joint from absence of the patella; congenital dislocation of the hip joint from insufficient development of the head and neck of the femur and of the acetabulum; the very rare congenital dislocation of the ankle in consequence of defect of the lower articular surface of the bones of the leg and of the astragalus, &c., an instance of which Volkmann[1] has described, in which it occurred in both father and son.

These deformities, resulting from defects in first formation, are not curable. We have even no means of replacing defects of formation. We can certainly fix a joint, deformed from defect, by means of bandages or splints, in a certain desired position, and the patient may, so long as he wears this apparatus, make tolerably good use of the limb; so soon, however, as the supporting help is withdrawn the old deformity re-establishes itself, for defects of first formation are never repaired. This is especially true in the case of congenital dislocation of the hip joint. We are assured by authors now and then that they have cured this deformity. But these assurances are to be accepted with doubt, since the most that can be done is to improve the function of the joint, and so enable the patient to hide the deformity as much as possible. A hip joint which is deficiently formed during intra-uterine life never becomes

[1] Volkmann, *Ein Fall von hereditärer congenitaler Luxation beider Sprunggelenke. Deutsch. Ztsch. f. Chir.* vol. 2. 1873.

normal. Certainly by means of a firm girdle placed round the pelvis, which either passes up in the form of arm crutches and downwards to the leg with a perineal band, one can limit the protuberance of the trochanter, and by retaining it for many years, by means of the apparatus, to the place which somewhat corresponds with the normal acetabulum, obtain a tolerably firm and correspondingly good functional connection; but one must never, therefore, fancy that a normal hip-joint has been formed and the case thus really cured. Such an achievement in the case of deformities arising from defective formation does not lie within the power of medical science.[1]

However, all congenital deformities do not arise from defects in formation, and the most frequent of all, congenital club-foot in its different forms of talipes varus, valgus, calcaneus, and equinus, is one of these exceptions to the rule. Up to the end of the last century this deformity was attributed to defect, and was looked upon as a malformation in its narrowest sense. This assumption has, however, been proved to have been incorrect in far the greater number of cases. Only in very rare instances do defects exist, as, for instance, when the peronei muscles are absent. In all other cases there is, on the contrary, no defect, either in the bone or in the muscles and tendons, and even the places of insertion of the tendons are found at the normal places. Club-foot has therefore, since the publication of the lucid work of Scarpa,[2] been regarded as a deformity, from mechanical causes, of an originally normally formed foot; and it is only with reference to the nature of the deforming forces that there still exists a want of unanimity, notwithstanding the most searching investigations on the subject. It is a question either of traction forces which exist in the body of the child—namely, in the muscles and tendons—or pressure forces, which the mother's uterus and the child's members effect upon one another. The reasons for and against these assumptions would take too long to discuss here in their entirety; I therefore confine myself to pointing out that both views have considerable reasons both for

[1] The latest record of a cure of this deformity is by Buckminster Brown, M.D., Boston, 1885.—N. S.

[2] Scarpa, *Memoria chirurgica sui piedi torti congeniti dei fanciulli et sulla maniera di corrigere questa deformità*. Pavia, 1803.

and against them, and that it may therefore be regarded as probable that they may both exist, and may not infrequently be combined. The problem which thus presents itself in respect to the cure of club-foot consists in the restoration of the foot from its abnormal to its normal position. This is best done by the strength of the hands, and by subsequent fixation of the foot in its improved position by means of bandages and splints.[1] If the obstacles which present themselves to the 'replacement' of the foot are too great to be overcome by the influence of strong hand pressure frequently repeated, it becomes necessary to divide the most tense and opposing tendons, particularly the tendo Achillis and the tendon of the tibialis posticus muscle, subcutaneously, and then to continue the correction of position. It is always, however, to be regretted when one is forced to have recourse to tenotomy, since those muscles the tendons of which have been divided remain notably weakened in function, whilst in the case of a club-foot cured by simple 'redressement' the functions of the muscles become perfectly normal. The patient cannot effect the cure of club-foot by his own active movement of, for instance, his peronei muscles, since he cannot exert sufficient strength for that purpose ; on the other hand, the function of the foot in walking exerts a decidedly redressing effect, only, however, when the foot has been so far restored towards its normal position that the sole touches the ground in its whole extent. If one can call the manipulatory movements employed by the surgeon gymnastic, then gymnastics play a large part in the treatment of club-foot.

Congenital wryneck (*caput obstipum congenitum*) is caused, as Stromeyer [2] was the first to prove, and as is now universally acknowledged, almost without exception, by injury of the sterno-cleido-mastoideus muscle at birth, and subsequent shortening at the place of injury by a cicatricial contraction.[3] This deformity occurs almost exclusively with children who have either been delivered by the forceps or more frequently in hip and foot presentations, from the greater traction upon

[1] Probably the most perfect application of mechanical appliances consists in directing the foot to be moved in a natural position by the exercise of its normal functions.—N. S.

[2] Stromeyer, *Beiträge zur operativen Orthopädik.* Hannover, 1838.

[3] This is by no means a universal opinion in England.—N. S.

the head required to effect delivery. Any attempt to produce elongation of the shortened muscles by passive movements and extension is in this case useless; on the other hand, the subcutaneous division of both heads of origin of the sterno-cleido-mastoideus muscle allows a rapid cure to be effected. In very rare cases wryneck is caused by a congenital deformity of the cervical vertebræ, which again is caused by intra-uterine pressure. I have had one of these rare cases under treatment. In such a case one must endeavour to bring back the crooked vertebral column into the normal position by permanent weight extension, with the addition of a frequently repeated redressing hand pressure, and to retain it there by means of instruments. As there is considerable deformity of bone, it is well to continue the treatment for some length of time and to be satisfied with the result of raising the head from its bent position, although it may not quite reach the median line.

For the 'acquired' deformities (arising after birth), a pressure similar to that exercised by the uterus upon the limbs of the fœtus only occurs in one case, viz. the oblique position of the big toe (*hallux valgus*). In this case the shoe plays the part of the uterus and pushes the toe outwards, whilst the head of the first metatarsal bone thickens considerably under the pressure by means of deposition of bone, and thus projects considerably at the inner side of the foot. A cure of this deformity necessitates so much and so prolonged inconvenience to the patient that it is really better to leave it alone. If the deformity becomes unbearable, the desirability or otherwise of exarticulation of the toe must be considered, for resection of the joint must not be thought of, because the removal of the head of the metatarsal bone would deprive the foot of one of its most essential supports.

The above referred to acquired deformities occur either from weight or muscular traction. The first is commonly called 'weight deformity,' the latter I would designate by the name of 'traction deformity.' In addition to these principal causes of deformity there are some others, though much rarer, which I will describe separately by-and-by.

The weight deformities of the joints of the lower extremities are flat-foot and genu valgum. In **flat-foot** the weight of the

body presses downwards through the bones of the leg and the astragalus on to the arch of the foot until the inner edge of the foot touches the ground in its entire length. The severe pains, which arise from the pressure of the inner edge of the foot against the ground, lead by reflex action in the worst cases to contraction of the peronei muscles, and eventually also of the gastrocnemius. By this contraction the deformity is increased, so that finally the inner edge of the foot becomes convex downwards, whilst the outer edge and the tuberosity of the os calcis are somewhat raised from the ground. Thus we have a case in which a typical weight deformity induces in its progress a contraction deformity, which latter increases the former. We shall later on have frequent opportunities of referring to this combination. The treatment of flat-foot in the case of young, quickly growing, but rather slender people of from fourteen to sixteen years of age, the chief subjects of this deformity, is at first prophylactic, and consists in procuring for them such an occupation as does not necessitate continued standing, and in which therefore the arch of the foot is not too heavily weighted. If this is not possible, or if the deformity has already appeared, we should endeavour, by means of an addition to the shoe of a pad of sole leather or an iron plate, or by means of a special orthopædic apparatus, the so-called flat-foot shoe, to support the inner edge of the foot, or even to raise it again. In the severer cases of contraction of the peronei and gastrocnemius it is desirable, according to Roser, to chloroform the patient to complete muscular relaxation, and then to restore the foot, as far as possible, to the normal position by a very powerful manual 'redressement'—not, however, to the extent of rupturing the tendons or fibres—and to fix it in that position by a plaster bandage for from four to six weeks. After the lapse of this time, the patient may resume his occupation, with the help of one or other of the above-mentioned supports. Tenotomy of the peronei tendons, or the tendo Achillis, should be resorted to in flat-foot only in cases of extreme necessity.[1]

The second weight deformity of a joint of the lower

[1] In addition to mechanical support, well-regulated exercises of the weak muscles are of the greatest value.—N. S.

extremities is **genu valgum**, which occurs in youth as well as in childhood, but does not increase after cessation of growth of the bone ; that is to say, not after the age of about twenty-three to twenty-five. The manner of origin of this deformity is as follows : Under normal conditions the line of weight of the leg (that is, the line perpendicular to the ground from the centre of the hip joint) passes to the middle of the knee joint, and then downwards along the tibia to the middle of the ankle joint, which latter is supported by the arch of the tarsus. This arch, independently of the form of the tarsal bones and their connections, finds an essential support by the ligaments from muscular power, while partly the muscles of the leg (the tibialis posticus, the flexor digitorum longus, and the flexor pollicis longus, with their tendons) and partly the short plantar muscles oppose any flattening thereof. The proper position of the line of weight passes exactly through the middle of the knee joint, because the muscles surrounding this joint stand to one another in an equal antagonism. Here, on the anterior surface, we find the extensor quadriceps muscle; posteriorly and externally, the biceps femoris ; posteriorly and internally, the semimembranosus and semitendinosus; and on the inner aspect, the adductors. If all these groups of muscles are well developed and of normal energy they keep the knee joint so completely in its place that no variation of position can occur. But these muscles are often weak and wanting in energy of action. This is especially the case with rickety children in early life, also in quickly growing young people at the age of puberty, who are employed in fatiguing occupations entailing long standing, as, for example, apprentices to joiners, bakers, locksmiths, &c. In order to avoid the painful feeling of fatigue during their work, these people seek a position in which they are able to preserve an erect attitude of the body, without being obliged to fix their knee joints in extension by sustained muscular action, and they attain this by slightly flexing one or both knee joints, and by rotating the limb at the hip joint so that the knee is turned inwards. In this position the knee joint is kept in equilibrium by tension of the internal lateral ligament, whilst the muscles are but slightly used. Thus the line of weight no longer falls exactly in the middle of the condyles of the

femur, but considerably farther outwards. In consequence of this the lower epiphysial line of the femur is under an unequal pressure; the outer half of it suffers an increase of pressure, as it has almost alone to bear the weight of the body; the inner half, on the other hand, is not only relieved from weight, but is even under a negative pressure, from the traction of the tense internal lateral ligaments. Such a difference of pressure, if it continued to a severe degree for a long time, would produce an unequal development of bone, even in a normal cartilaginous line of epiphysis; on the inside a more rapid, and on the outside a slower growth of bone. But, at the ages mentioned above, abnormalities often exist which may increase such influence to a very considerable degree. In children rickets is a common cause for rendering the bones, not only in the diaphyses but also on the borders of growth of the epiphysial lines, inclined to yield to pressure; and at the period of puberty there is often, as Miculicz [1] first demonstrated, particularly in the case of the half-grown people described above, an alteration in the epiphysial lines, especially of those of the condyles of the femur and tibia, a condition which strongly resembles the rickets of infancy, and therefore is designated by the name of 'rickets of adolescence.' The epiphysial line, for instance, is considerably widened, the proliferated cartilaginous layer being especially thickened, so that upon section its tissue protrudes beyond the sawn surface. Under these abnormal conditions the epiphysial cartilage, restricted in its power of resistance, responds to the unequal pressure by producing unequal bone-formation. The bone-formation in the outer half is retarded; the inner half, being relieved from pressure, quickly increases in substance, and thus it happens that the inner condyle of the femur gradually becomes lower than the outer. Similar conditions prevail on the upper epiphysial line of the tibia, although here they are generally less marked. When the knee joint, under the influence of these conditions, is turned much inwards, then the weight of the body, acting upon the leg, which is thus displaced, almost always produces secondarily a bending of the upper end of the tibia with a convexity directed inwards, for

[1] Miculicz, *Die seitlichen Verkrümmungen am Knie und deren Heilungsmethoden.* Archiv f. klinische Chirurgie. Bd. 23, s. 561. 1879.

the line of weight bears upon this bone at a considerable angle, whilst the diaphysis of the femur, the axis of which in effect corresponds with the line of weight, experiences no such secondary deformity. The tendon of the extensor quadriceps femoris with the patella is displaced considerably too much outwards as regards the muscles surrounding the knee joint, and the biceps tendon becomes prominent on the outside of the knee joint, like a tightly drawn cord. But neither change must be looked upon as entirely primary; they have not produced the valgus position, but they are the consequence of it, caused by the lateral displacement and partial approximation of their points of insertion. Flexion of the knee joint is in no way hindered by the valgus position, extension is generally increased to a slight degree of hyperextension.[1] With increasing flexion the valgus angle diminishes, and in the rectangular position generally disappears entirely. This circumstance, which at first sight is very surprising, is explained by the oblique direction of the axis of rotation of the knee joint caused by the low position of the internal condyle. If one takes a straight rod (see fig. 1), which is interrupted by a hinge joint situated transversely to its longitudinal axis, as at *a*, the rod can be moved in all degrees of flexion, even up to complete extension in the same plane. If, however, the joint is made obliquely to the longitudinal axis of the rod, as at *b*, the latter remains straight when fully extended, but the more it is bent the more it deviates from the previous plane of flexion. If one takes a rod which at fullest extension is angular, as at *c*, with the hinge at the place of the angle, the angle will diminish as the lower part is bent upon the upper, and disappears entirely when the bend reaches 180°. This is the reason why in genu valgum there is diminution of the valgus

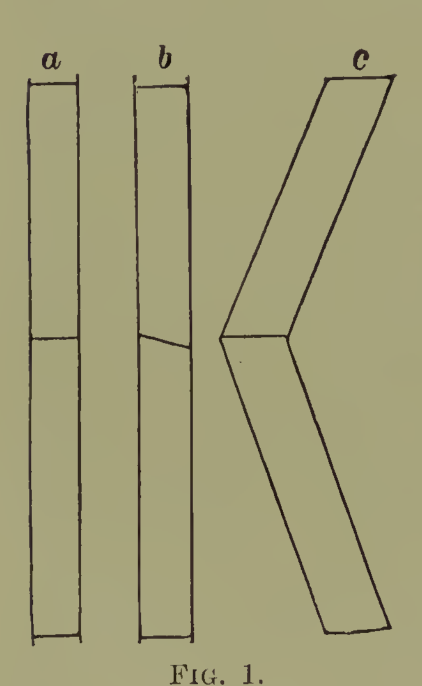


Fig. 1.

[1] In many cases the range of extension has been found to be lessened.—N. S.

position with increasing flexion, and if the mechanical conditions in a deviated knee joint are much more complicated than in the angularly bent rod, yet here the obliquely directed axis of rotation is similarly the principal cause for the removal of the valgus position when the leg is bent upon the thigh. It results from this mode of origin that genu valgum is not in any way amenable to treatment by gymnastics or massage. Neither general nor localised muscular movements are able to effect the slightest result as regards the correction of genu valgum; and if we attempt, as is often done, to counteract the valgus position in extreme extension by passive side movements, one may indeed stretch the lateral ligaments of the knee joint and loosen the joint, but a correction of the position cannot thus be effected. Neither is tenotomy of any use for the cure of genu valgum. If performed, as has often enough been done, upon the tendon of the biceps muscle, or on the external lateral ligament of the knee joint, one may certainly place the joint straight, but only by means of separating the outer surfaces of the joint from one another and by making them gape. If we fix the leg in this position with a plaster bandage we find, after a tolerably long time, that the old conditions invariably remain, *i.e.* gaping outer condyles and a lengthened and weakened external lateral ligament, and as soon as the patient tries to support himself upon his leg the old abnormal position re-establishes itself. In consequence of this, all attempts to cure genu valgum by means of tenotomy should be abandoned.

We are, however, able to cure many cases of genu valgum by means of an instrument which alters the conditions of pressure. An iron splint is attached to the outside of the leg, bent precisely to accord with the abnormal angle, and is then gradually straitened by means of a rack joint. Thus the knee joint is drawn outwards, and whilst it relieves the external surfaces of the joint from pressure, on the other hand it presses the internal surfaces firmly against one another; it effects the reversal of the unequal bone-formation caused by the genu valgum on the lower epiphysial line of the femur. The working of the machine is more effectual the longer are the arms of leverage. The lower arm should extend to the external malleolus, the upper should bridge over the hip with an inter-

vening joint and be fixed to a well-padded pelvic belt. There is no difficulty in making the extension effected by this machine an elastic one. With this machine one has been able to cure, in the course of from one year to one year and a half up to the age of twenty even, great irregularities of the knee joint. Beyond the twentieth year the bones are so firm, and the alterations of growth in them so slight, that the machine is no longer able to produce any effect. But even in earlier years adverse circumstances often occur, inasmuch as these patients mostly belong to the poorer classes and are compelled to earn their living by bodily labour, and are therefore not able to submit to so long an instrumental treatment.[1] In this case we must cut instead of disentangling the knot—*i.e.* one must procure the correction of the position by breaking or cutting through the deformed bones.

The *redressement forcé* was introduced by Delore,[2] of Lyons, but only as practicable for genu valgum in infants and children up to the age of ten. The patient was chloroformed, then laid upon that side upon which the genu valgum was situated, and a powerful pressure exercised upon the inside of the deformed knee joint, until the leg touched the horizontal table with its outer surface. In this position it was fixed for from four to six weeks by means of a plaster bandage, and then free movement was permitted to the patient with the aid of a supporting machine. By this method the 'redressement' is performed by means of the traumatic separation of the epiphysis of the femur or tibia, which subsequently unites in the plaster casing. The advantage of the method is its speedy result; it is, however, to be feared that traumatic separation of the epiphyses may affect unfavourably the subsequent growth of bone. Beyond the tenth to twelfth years correction of the valgus position is not to be effected by forced 'redressement.' The epiphysial lines have then become thin cartilaginous discs, which can no longer yield to pressure, and if any great force were to be exerted, the

[1] If instrumental treatment is conducted in the manner advised by me in *The Surgery of Deformities*, 1882, the patients need not be incapacitated for work for a single ay. In fact they are often by such means enabled to do their work much more easily.—N. S.

[2] Delore, *Du mécanisme du genou en dedans et de son traitement par le décollement des epiphyses.* Gazette hebdomadaire, 1874. No. 8.

external lateral ligament of the knee joint would be torn, and thus produce conditions which would be quite as unfavourable as subcutaneous division of this ligament. If the patient, having passed his twelfth year, is so unfavourably situated as to be unable to undergo treatment by slow reduction by an instrument, he must submit to osteotomy, and for patients beyond the age of twenty, osteotomy is the only possible method of cure. This operation may be performed in three different places, viz. first, on the tibia at the level of the tuberosity; second, on the diaphysis of the femur just above the condyles, and therefore just beyond the knee joint; third, on the femur by separation of the inner condyle involving the knee joint.

First. In osteotomy of the tibia, the skin, fascia, and periosteum are divided by a transverse incision at the level of the tuberosity, and the exposed bony wall is then cut through with a few strong blows on a chisel, the chisel being directed evenly against the angle of the bone, which is here triangular. The separation of the rest of the bone, which is divided towards the ligamentum interosseum, is completed by breaking, such a force being exerted as to make the bony fissure gape. There are several advantages to be gained by completing the operation by breaking the last bony fibres. If we divided this part with the chisel, it might very easily happen that the sharp corner of the instrument might injure the anterior tibial artery, which lies immediately behind the bone where it passes through the interosseous ligament, and it would then be quite impossible to stop the bleeding by tying, because the artery could not be reached. It would therefore be necessary to ligature the femoral artery, and it is well known that under such circumstances, although the bleeding might be arrested for a few days, it is probable that later on a secondary hæmorrhage would very likely occur, only to be stopped by amputation. Moreover, it is of importance, for the healing of the divided bone, that it should not consist in its whole extent of a smooth chiselled surface, but that in one part of it a jagged surface of bone should exist. This condition is a great security against displacement of the bone. The division of the bone being thus performed, we attempt the correction of the malposition, by drawing the lower long fragment of the tibia from its out-

ward position towards the median line. If, when this is done, it is found that the anterior part of the divided bone prevents the perfect adaptation of the surfaces to one another, we must ehisel them away until the eorreetion can be properly effected. This operation always suffiees to remove the outward deflexion of the tibia, and therefore there can be no neeessity for a wedge ineision. The saw is quite unsuited to this osteotomy; the chisel is, therefore, the only available instrument, besides being, as Volkmann rightly remarks, a mueh more efficient one. The wound is then treated like a compound fracture by Lister's method, and its healing may be safely obtained by a thorough use of antisepties.

Seeondly. Osteotomy through the diaphysis of the femur, above the eondyles (Maeewen's operation), requires an ineision on the outside of the thigh, whieh, by dividing the skin and fascia, the extensor quadrieeps and bieeps museles, and penetrating the loose eonneetive tissue, renders the bone aecessible. A few strong strokes with the mallet upon the ehisel almost eompletely divide the bone, and the separation is eompleted by fraeture. The femoral or popliteal artery is eertainly somewhat near to this place of division, but it can be avoided if suffieient eare be taken. When the division is aceomplished the position can be correeted without diffieulty.

Thirdly. The third plan of osteotomy was published in the year 1876, by Alexander Ogston, of Aberdeen. It eonsists in first obtaining aeeess to the internal eondyle of the femur by an ineision; then a narrow saw is introduced through the incision into the knee joint; this condyle is boldly sawn inside the joint obliquely to the intercondyloid fossa and the division eompleted by fraeture. When the leg is now moved out of the valgus position towards the median line, the divided inner condyle is pushed upwards, and thus the 'redressement' is effected. By antiseptie treatment carried out with extreme eare even this serious wound often heals without suppuration. If, however, any slight want of care occurs, and suppuration consequently ensues, then the patient's life is in the greatest danger, and is only to be saved by amputation.

The result of a eritical eomparison of these three methods of osteotomy is the judgment that Ogston's method is to be

regarded as one to be abandoned, for although we must admit that even with antiseptic precautions a thoroughly experienced surgeon may perform even this operation without very much risk, yet the mechanism of the knee joint suffers so severely through the uncontrollable action of the saw, that very considerable disturbances occur in the functions of the joint later on.[1] The leg certainly assumes a straight position, but the functions of the joint are so much interfered with, that as much disability may ensue as in the original genu valgum. Both the other osteotomies are performed outside the joint. Which of them is to be preferred has not yet been determined with certainty, owing to the novelty of the whole method. I personally would always begin with the osteotomy of the tibia, since this, in consequence of the superficial position of the bone, may be performed more easily and more safely. If, however, this osteotomy does not suffice to rectify the valgus position, we may be subsequently obliged to supplement it by osteotomy of the femur.

For the deformity of genu valgum exists in both bones, as has been explained above—*i.e.* in the tibia as well as in the femur. In the first, it is the bend in the upper extremity of the bone, and in the latter the low position of the inner condyle. Each of these two osteotomies rectifies only one of these deformities, and it may therefore be necessary to divide both bones. If we should attempt to correct a very severe genu valgum by division, bringing the leg at once to a straight position—which, indeed, might be done—then a bayonet-shaped position would result; while at the place of osteotomy an angular bend of the bone would be caused with the angle directed inwards. Nevertheless, I believe that the necessity for a double osteotomy seldom occurs. Osteotomy of the tibia is found to suffice even in severe cases to correct the position of the leg, so far as to make it a sufficient support for the body, and this, and not exact symmetry, is what is obtained in these

[1] At the International Medical Congress at Copenhagen (1884), Dr. Ogston stated that, although he was still in favour of his own plan in some cases, yet he admitted that Dr. Macewen's procedure was, for the majority of cases, the better operation. There is a slight error in the above description of Macewen's procedure, for he operates from the inner side of the femur.—N. S.

cases. There are, however, many surgeons who consider osteotomy of the diaphysis of the femur the more important and more successful operation.[1]

In the hip joint, on account of the deep insertion of the head of the femur into the acetabulum, weight deformity does not occur. However much it may be affected by weight, no alteration in the relative position of the two bones which form the articulation can be produced. Excessive long-continued pressure may depress the neck of the thigh, and thus lessen the angle which the head forms with the shaft of the bone. Very great and sudden efforts may break the bone, or the joint mechanism may be greatly disturbed by dislocation, but weight deformity proper, such as those occurring at the knee and foot, cannot happen in the hip joint on account of its mechanical construction.

Apart from the joints, weight causes not infrequently deformities in the continuity of the bone itself. The preliminary condition necessary for this, which in fact forms the predisposition to it, is a diminution in the firmness and power of resistance of the bone-substance. This may be effected by two diseases, viz. **rickets** and **osteomalacia.** A third disease, which sometimes so weakens the bone-substance that it bends under pressure, is diffuse cancer, but this is so rare and is so far beyond treatment, that this reference to it may suffice. Bendings of the bones from rickets and osteomalacia are undoubtedly principally caused by weight; muscular contraction however, plays a part in the production of these deformities, which, though certainly a secondary one, is not to be overlooked.

Bendings from osteomalacia are but seldom an object of treatment, as they are generally diffused over so large a portion of the skeleton that no firm basis exists for the efficient support of mechanical appliances; and further, because the fundamental evil menaces life to so great a degree that it is of no importance to endeavour to rectify one bent bone. But rickety bendings of bone afford an extensive field for

[1] A valuable paper upon Osteotomy for genu valgum was read at the International Medical Congress at Copenhagen, in 1884, and published in the *Lancet* of Sept. 27, 1884.—N. S.

orthopædic surgery. In these cases the most striking fact is that rickety bent bones are able to effect a considerable degree of spontaneous correction in the further course of growth. Rickety bent leg-bones with the convexity outwards, which are so often seen in children of the poorer classes, may become so straight in the course of further growth, without any treatment, that scarcely any trace remains of their early deformity. The manner in which this rectification takes place cannot be satisfactorily explained, for weight as well as muscular contraction must operate by increasing the curvature, or at least by opposing its removal.

The cause of the spontaneous correction of rickety bent bones most probably lies in the conditions of the bone-growth, perhaps in such a manner that after the cessation of the rachitic process at the cartilaginous epiphysial lines a normal growth of bone occurs, which produces the further growth in length of the bone in a straight direction, whilst on the convexity of the curve a process of absorption takes place with corresponding deposition of bone on the concave aspect. In this manner the bone may gradually adapt itself to the direction of the tendons of which it formed the arc at the time of the curvature. One cannot suppose that the bone can ever straighten itself by its own elasticity, after the manner of a bent twig, as soon as the forces cease which have bent it. There are, however, limits to the spontaneous correction of a rickety bent bone. Very severe deformities do not correct themselves, or at least do so but very imperfectly. Thus tibiæ bent forwards in the form of a sabre sheath do not return to the normal form, and rickety bent femora do not easily lose an abnormal outward curve. As to treatment, this should at first, during the existence of rickets, be directed as far as possible to the prevention of curvatures. This is certainly more easily said than done, for children affected by this disease are so difficult to treat at this early period, that a prophylactic attempt against the occurrence of bone curves is only possible in the smallest degree. If crookedness remains after perfect cure of the disease, then the bones have the well-known hardness of eburnation, which makes correction much more difficult.

The means which may be had recourse to during the early

period of these deformities for orthopædic correction are as follows:—

First, we may endeavour by manual efforts to restore the bent bones to a straight position. Strong pressure against the convexity and a bending back in both ends of the bone, if it is continued for a very long time and with great force, may possibly effect a 'redressement.' It is a very necessary condition for a favourable result, that the disease has not existed too long, but that the bones present a certain amount of rickety softness. If the eburnation stage has become well established, then certainly no such mild means will have effect upon the hard bone.

The second method is the straightening by means of splints: we place a tolerably strong splint to the concavity of the crooked bone, and then draw the bone powerfully, by means of leather straps or elastic bands, to the splint. This method is often practised; it is based upon simple principles, and is attended by no evil result except the mere weighting of the part, and if it cannot be regarded as a very successful means of straightening, it is, nevertheless, undoubtedly sufficient to assist the above described spontaneous correction during advancing growth in a favourable manner. It is certainly necessary that the bending of the bone should be of such a kind that the splint may be easily applied, as in the curving of the leg-bone with the convexity directed outwards. If the convexity of the curve is directed forwards, this method cannot be adopted, for on the one hand the splint can hardly be applied to the hinder surface of the leg, and on the other, the slightest pressure would at once cause pain and set up irritation, as the skin is here immediately pressed against the sharp angle of the tibia.[1] For the same reason, this method is inapplicable to crooked thighs with the usual convexity outwards and forwards, for in this case the splint would be thrust against the perinæum.

The last and most effective means of correction consists in the subcutaneous fracture of the bone, or in osteotomy. The

[1] These are certainly very difficult cases to deal with, but by means of well-padded and accurately moulded plates applied to the projecting angle and drawn by straps to a back splint taking its bearing from the boot, an efficient pressure can be applied. Of course such cases necessitate much care and attention, and the exact point of pressure must be altered frequently.—N. S.

first has this recommendation, that it causes no external wound, and therefore only involves simple healing, as in a subcutaneous fracture. It is, however, not so easy to break a bone subcutaneously as one might imagine. If the eburnation stage has set in, all the strength of a strong man may be insufficient to break the leg-bone of a child of from 3 to 4 years old, and even when the fracture is effected, it is very often not situated in the desired place, and therefore is not followed by the desired result for the correction of the deformity. A more certain localisation of the fracture can perhaps be effected by Rizzoli's osteoclast, but I have no personal experience of its use.

The last means is the division of the bone by open wound at the most prominent point of the deformity. After the most careful cleansing and disinfection of the field of operation, as well as of all the objects which would come in contact with the wound, the bone is exposed by means of a longitudinal incision at the place of the deformity and divided by a few blows upon a chisel. The bone is then straightened, and the case is treated as one of compound fracture. If, after the division, it appears that it is not possible to straighten the limb because the bone edges are opposed to one another, it is necessary to chisel as much away from these edges as suffices to permit the correction to be made.

For this correction also the chisel is far preferable to the saw, as it produces no contusion of the soft parts, leaves behind no foreign body such as detritus, and above all can be used even at very considerable depth, and produces a surface of bone which easily and quickly consolidates, whilst two sawn surfaces placed against one another cause no small risk of the formation of a false joint. The same method may also be adopted for the correction of obliquely united fractures. If antiseptic treatment be thoroughly carried out the healing may be expected with certainty, and the operation regarded as free from danger. This security may have rendered surgeons, especially in Germany, somewhat too disposed in the course of this last year to have recourse to osteotomy, even in cases in which hopes might still have been entertained of a cure by pressure. Moreover, it must be remembered, that the division of the bone is not without effect upon the subsequent bone-forma-

tion, since an osteotomised bone does not readily attain the slender form which a rickety bone that has become straight spontaneously often later on presents. It is therefore advisable that we should be more sparing of osteotomy than hitherto, and that we should reserve this very satisfactory operation for those cases in which cure by pressure is no longer expected.

The next large group of deformities of the lower extremities consists of anomalies of position after the cessation of joint-inflammation. These are principally contraction deformities; that is, they are produced and maintained by muscular or cicatricial contraction. But it must not be overlooked that even in these cases weight also plays a considerable part. As we well know, every inflamed joint assumes an abnormal position. At the commencement of inflammation of the hip-joint the limb is flexed, abducted, and rotated outwards, and in the further course of the disease becomes flexed, adducted, and rotated inwards. In inflammation of the knee joint the leg becomes flexed, and the foot joint, when the ankle is diseased, assumes the equinus position. Both the first joints produce this variation in position, undoubtedly on account of muscular contraction without the effect of weight, even in opposition to weight. This muscular contraction is either of a reflex character, upon which the will of the patient has no influence, or it is instinctive; that is, the patient places the diseased limb by voluntary effort, but without distinct consciousness, in that position in which it is least painful. The effect of pressure of an interarticular effusion upon the extended capsule, as Bonnet instances in explanation of this position, may be excluded with certainty as a simple mechanical influence, and can at most come under consideration with reference to the instinctive adoption of position, in so far as the patient finds out the position in which the articular capsule presents its greatest capacity and a uniform tension of its wall. If in the further course of inflammation the bone becomes carious, then weight always has much more influence, and may materially help to produce a particular kind of deformity. The fixation of the deformity after the cessation of the inflammation is caused by cicatricial contraction of the articular capsule, of the muscles, fasciæ and ligaments surrounding it, as well as by morbid growth of con-

nective tissue, cartilage or bone, upon the surface of the joint which has been eroded by the inflammation. The foot joint is an exception, in so far as malposition of talipes equinus, with inclination to varus already commenced, is almost always caused by weight with only slight muscular contraction. Subsequently, however, fixation is the same as in the other joints.

To treat a joint when acutely inflamed by active or passive movements, as has been discussed from a gymnastic but not from a medical point of view, is a bold venture, the result of which is usually unfavourable. In many cases the attempt causes enormous suffering, chloroform has to be administered in order to permit of the movements being performed, and even then we may with certainty affirm that, in every case, the effect of each movement is injurious. But even in those cases in which the suffering is not so severe, a movement cure can hardly be recommended, as it seldom results in the cure of the patient. Rest and extension are the true requirements which are needed by an inflamed joint; rest which hinders the rubbing of one inflamed bone against the other, and extension which removes the injurious pressure which the inflamed articular surfaces exert upon one another from muscular contraction or weight. Of these influences (rest and extension), the last is even more important than the first. Prevention of the friction of the joint surfaces does much good, but removal of the opposing pressure, or even contact, effects more good. Repose can be obtained, in addition to simply lying in bed, by the use of stiff bandages, fixing appliances or splints; extension, by a weight fastened to the lower part of the leg and hanging freely over a pulley. Rest has already been shown to be a necessity for inflamed joints, and Bonnet has been its most eloquent advocate; extension has only been developed during a little over ten years, since the use of adhesive plaster as a means of fastening the weight, and Volkmann is its most zealous supporter.

With respect to rest of the inflamed joint, it is not a matter of indifference in what position the limb is placed. The proposition of Bonnet is usually approved of, that we should fix the inflamed joint in that position in which, in case the inflam-

mation results in ankylosis, the patient would be best able to make use of the limb. For the foot joint this position is a right angle, and for the knee and hip joints full extension.[1] If the diseased joint at the time at which healing begins is in another position, it is necessary to correct it before we proceed to fix the limb. If pain and muscular tension greatly oppose this correction, it then becomes necessary to resort to an anæsthetic, and then to complete the correction of the position. This 'reduction' if performed at once under complete anæsthesia, with immediate subsequent fixation of the limb, can be effected with a considerable expenditure of force, without causing an increase of inflammation. It is often advisable, with the hip joint especially, to withdraw the leg from its position of flexion, adduction and rotation inwards, with considerable strength into the simply extended position. The joint may be fixed either by means of stiff bandages, splints, or other appliances.[2] For the foot joint, the plaster bandage appears the most effective ; nevertheless, it has the disadvantage of keeping the diseased part covered, and thus withdrawing it from inspection, and also from external applications. More useful in this respect are Heister's leg-case—the cradle, and the well-known wooden hollow splint with a perpendicular footpiece. For the knee joint, at the present time as for a series of years past, the plaster bandage has been the means most often used for fixation, and one can, by cutting a large window in it on the front surface, leave the joint sufficiently free for inspection and for applications. If necessary, however, we may fix this joint sufficiently well by the cradle or the hollow splint. For the hip joint, especially in coxitis of childhood, the plaster bandage was, ten years ago, the most frequently employed method of treatment, but since permanent extension has so completely taken its place this has been very seldom used. Splint apparatus have not been much used for these cases since the time of Bonnet's cradle, which for a long time played a conspicuous part in surgery, but has proved much too cumbrous and inefficient for fixation. Extension ought to lessen the pressure which the diseased joint surfaces exert upon each other,

[1] In the case of the knee very slight flexion is probably better.—N. S.

[2] See *The Surgery of Deformities*, p. 124 *et seq.*—N. S.

and it may be applied so as to separate the articular surfaces from one another entirely, so that they shall no longer touch, because in this manner the pain is considerably lessened and the perfect cure of the ulcerated portions of bone more easily brought about.[1] In order to elucidate the very complicated changes which the dragging effect of a weight produces upon the position of the joints, the capacity of the articular capsule, the interarticular pressure, as well as upon the position of the opposed joint surface, Reyher[2] made careful experiments on the knee joint in the cadaver. He found that continuous traction at first, whilst it extends the knee joint out of a slightly flexed position into one of full extension, decreases the capacity of the articular cavity, and in consequence of this, in cases when this cavity is filled with fluid, increases the pressure. Further increase of the extension by weight, up to at least twelve pounds, lessened the pressure and counter-pressure which the articular extremities exerted against one another, and finally produced a separation of these of from one to three and a half millimetres, upon which the pressure of the fluid in the articular cavity was reduced. Reyher accordingly attributes the favourable effect of permanent extension upon inflammations of joints, especially of the knee joint, to the following three factors: First, the immobilisation of the joint; secondly, the change of the point of contact of the joint cartilage, and the increase of the interarticular pressure, which occur when only sufficient weight is applied just to effect extension, *i.e.* for adults from eight to ten pounds; thirdly, the decrease of the pressure and counter-pressure of the articular surfaces upon one another, *i.e.* their complete separation, when a greater weight (at least twelve pounds) is applied; the result being an increase of the interarticular fluid pressure on closed joints, which only diminishes again upon the separation of the articular surfaces, but which is never quite removed.

In the application of these results of experiments made

[1] It may be remarked that the capsule and adjacent structures may also be inflamed, in which cases perfect fixation without extension produces equally good or sometimes better results.—N. S.

[2] Reyher, 'Die Behandlung der Kniegelenksentzündung mittelst der permanenten Distraction,' *Deutsche Zeitschrift für Chirurgie*, vol. iv. pp. 26–89. 1874.

upon the dead body to the conditions existing in the living, however, a decided distinction must be made. The ligaments of a dead body are stiff fibrous bands, which only slightly lengthen after very considerable traction, and upon cessation of the traction immediately return to their former length. The conditions in the living body are essentially different. If in this case a ligament is exposed to a tolerably powerful and continuous traction by weight it lengthens, whilst its cells furnish an interstitial deposition of new tissue-elements which effect a permanent elongation of the ligament. Thus it is a very frequent occurrence that with permanent weight-extension upon the leg, the ligaments of the knee joint elongate to such an extent that there may be considerable lateral movement in this joint when fully extended, which endangers its firmness very considerably.[1] There can be no doubt, therefore, that great weight-extension may produce a real separation of the articular surfaces. For the foot joint, extension cannot be applied, because here the peripheral part, that is, the foot, does not present a sufficient extent of surface to which to fasten the weight. For the knee joint, extension could be made, but in most cases it possesses no great advantage over bandages and instruments; for the hip joint, on the other hand, extension is of the greatest importance; so much so, that for this joint this plan has superseded all other methods of treatment. Extension here is carried out as follows: A braced band of adhesive plaster is carried from the middle of the thigh laterally over the knee joint and downwards, bent under the foot like a stirrup at some little distance from it, and then carried up to the other side of the leg to the same height; circular strips of adhesive plaster fix this in its place, and a flannel bandage placed round secures the uniform application of the plaster. In the stirrup-shaped loop a piece of wood is inserted crossways and the weight fastened to this with a cord, and allowed to hang free over a roller at the foot of the bed. For children up to 10 years of age from 3 lbs. to 8 lbs. is a sufficient weight; for older children and grown-up people we may, however, use one up to 15 lbs. In order to hinder the swinging of the foot and diminish friction,

[1] See Papers by J. Jones, M.R.C.S., *Lancet*, Feb. 12, 1881, and March 10, 1883.—N. S.

the foot is fastened to the Volkmann's looped foot-band. If heavy weights are used, it is necessary to fix the body so that it may not be drawn by the weight towards the foot of the bed. Sometimes it is sufficient to raise the foot end of the bed by means of a brick or piece of wood, and thus to secure an oblique position sloping down towards the head-board. If this means is not sufficient a counter-extension perineal band must be applied and fastened to the head of the bed. If the diseased leg is in the position of adduction, then we should place the perineal band on the sound side ; if, however, it is in abduction, the band must be placed on the diseased side, by which means the defective positions are best corrected. Under the influence of traction, the pain and muscular contractions generally soon subside, and thus the conditions favour a rapid cure in a good position. Permanent extension obtained in this manner is now applied in all forms of coxitis and for fractures of the cervix femoris, as well as of the upper third of the thigh. For fractures situated lower down it is less suitable, as the mechanical conditions are different; and here the plaster bandage remains, as before, the most advantageous method of treatment.

Now if rest and extension are successful in relieving the acute stage of inflammation, the necessity arises for restoring to the joint, as much as possible, its normal movement, so that it shall not be ankylosed, although in a favourable position. This can only be accomplished by exercising the joint by passive movements, contraction of the ligaments of the articular capsule being counteracted by repeated stretchings. Bonnet has paid great attention to this point and constructed a number of machines for exercising separate joints, which are set in motion either by the patient or by attendants. These machines are in some respects very effective, but they may nevertheless be replaced and even surpassed by the hand of an expert man specially trained in these movements. In any case, such a person must possess, besides skill and strength, aptitude for attention to all the details of manipulative treatment, for it is an extremely difficult and even dangerous undertaking to restore the movement of joints, fixed by acute inflammation, by means of systematic passive exercises. The danger is, that too energetic or long-continued movement may cause a return of

the acute inflammation. The greatest care both of patient and surgeon often fail for this reason. Some inflamed joints, which remain very irritable even a long time after the cessation of the acute stage, and in which every attempt to restore movement is consequently followed by a return of the inflammation, will necessitate a further course of treatment by rest, extension, cold, and even sometimes the local abstraction of blood. In these cases no care will prevent the occurrence of ankylosis, which proceeds unchecked. Now a movable joint is preferable to one which is ankylosed, even in a good position. The principal requirement for the functional capacity of a joint of the lower extremities is that it should afford a firm support for the body. For this reason a joint which is persistently painful, or which suffers a return of inflammation whenever it is mechanically treated, is much worse than a firmly ankylosed joint. The worst of all, however, is an unsteady joint, which in consequence of disease of the ligaments and bone surfaces has lost its firmness, and is thus unable to afford any support for the body. The treatment after cessation of the acute stage of inflammation should be directed, therefore, mainly to the restoration of the normal mobility. The attainment of this end makes very great demands upon the skill and perseverance of the surgeon. Many will fail where others are able to attain a good result, just as a tight stricture which may be impermeable to many, will be found passable by a specially skilled hand. We must not therefore be discouraged by a failure in the first instance, but must proceed with more careful observation of the general and local conditions. We shall derive great assistance from the use of warm baths, and to some extent from warm jet or steam douches. If, however, we find later on that the sufferings and danger caused by the attempt at restoration of movement are too great, then we must abandon the first object and attend to the second, namely, the attainment of ankylosis in a favourable position. The means of attaining this object consists in fixing the joint in the desired position by means of a stiff bandage, such as plaster of Paris or silica, or by splints kept on for a long time. The patient can also make his first attempt at walking with these bandages or apparatus. When firm ankylosis is obtained, the treatment of a case may be considered at an end ;

although the usefulness of the leg is certainly much less than in its normal condition, yet it may be of such a kind as to suffice for the patient, even in a rather fatiguing employment. If the joint remains painful notwithstanding every attempt at cure, or is exposed to constant inflammatory relapses, then, after all milder means are exhausted, serious surgical measures may come into consideration, such as incision and draining under antiseptic precautions, tapping, resection, and in extreme cases even amputation. The same measures may have to be considered in respect to a loose joint, though, before resorting to such treatment, we must first endeavour to restore the defective firmness of the joint by a supporting apparatus.

The opportunities for the restoration of movement are more favourable in those cases in which the joint has not been inflamed, but has lost a portion of its mobility in consequence of long inactivity. This happens especially in the case of fractures. In order to bring the fracture into a favourable position for a cure, it is necessary to fix for some time not only the broken bone but also the neighbouring joints. Every such fixation produces a diminution in the range of movement of the joint, as the articular capsule and the supporting ligaments become contracted, corresponding to the position at the time; and, in consequence of deficient secretion of the synovia, the joint becomes dry, so that the movements are attended with great friction. The nearer the fracture is situated to a joint the greater are the disturbances, and if the fracture penetrates into the articular cavity itself, then the conditions are especially unfavourable. This proximity of the fracture causes, by extension of the irritation, first, increased proliferation in the joint, and later on contraction, but the penetration of the fracture into the articular cavity, even if it happens to prevent displacement of the fragments, causes irregularity of the articular surfaces from the growth of callus, and may even induce ankylosis by extension of the inflammatory bone-formation to the articular capsule and ligaments. In all these cases passive and, as soon as possible, active movements are highly beneficial. When the fracture is cured, then it is always necessary to release the limb and to begin movements. Here, too, a slow and regular procedure is always advisable; too violent measures may produce

inflammation, which, even if not easily changed into suppuration, is nevertheless very deleterious in the form of inflammatory serous effusion, and compels long interruption to treatment.

Here, too, warm baths are of great assistance, but in severe fracture generally months and even years elapse before the joints regain their normal range of action. In the case of old persons and in unsuccessful treatment of intra-articular fractures, the affected joints often do not regain their functions. This is especially to be dreaded in fractures of the femur in old people, in which cases, even when no false joint occurs, but the cure proceeds by firm bony callus, yet the mobility of the hip joint almost always suffers great and permanent derangement.

If firm ankylosis has taken place in an unfavourable position, in consequence of unsuccessful treatment of an acute joint inflammation, it is necessary to bring it into a more favourable position by powerful manipulation (*brisement forcé*) under chloroform. If the strength of the hands be not sufficient, we must have recourse to a pulley in the form of Schneider-Mennel's extension apparatus, or some redressing machine, which by means of powerful levers admits of the employment of very considerable force. The 'reduction' is effected by tearing the fibrous adhesions which fix the joint surfaces in the bad position. When the desired position is reached, the joint is fixed by a plaster bandage in order to produce ankylosis. Restoration of mobility is in these cases so hopeless that any attempt to procure it would involve a waste of time.

Burns of large extent often produce cicatrices which contract the joints into defective positions. In the treatment of a recent burn the greatest possible care should be taken that no deformity of a joint occurs; it is not, however, always possible to prevent this result. For example, if the burn is situated on the posterior surface of the thigh, we are not often able to procure fixation of the joint in the position of extension; for, if we persisted in doing so, the granulations of the wound would eventually increase and bleed, but would cicatrise no longer, because the surrounding skin would be already too tense to admit of this result. In such cases we must abandon extension, and then the granulating surface will cicatrise, but at the same time will flex the knee. We have become possessed of late of

very effectual methods for successfully opposing the contraction of the cicatrices, in the skin-grafting of Reverdin and also in the use of dressings, but an extensive and deep burn still entails great danger of cicatricial contraction. If such contraction has occurred and a joint is thereby deformed, there is hardly anything to be done for it. Every attempt at extension fails, either from the great resistance or by the production of rents in the cicatrix, which are very painful and require lengthened repose for a perfect cure, during which the old condition returns. To divide the cicatrix and to transplant a stalked flap of skin in the gaping interval is only possible for the face, as only the skin of the face is suitable for such treatment. We cannot, therefore, always remove cicatricial contractions once formed, but can counteract their formation to a considerable degree at the time when the burns are fresh, by means of the methods described above.

The third large group of joint deformities of the lower extremities is that of **paralytic deformities.** For the cause of these I confine myself in all particulars to Seeligmüller's explanation. If several muscles which surround a joint are paralysed a definite deformity never, or at least extremely seldom, takes place. The passive mobility of the affected joint is not only preserved but even unavoidably increased, as every muscular interference is removed and the ligaments stretch in the course of time. Influenced by weight alone the joint assumes a position corresponding to the position of the body. It is not fixed there, but may be brought by external influence into any other desired position. A 'swinging leg' is the distinctive appellation bestowed upon this condition by the English. On the other hand, if only a portion of the muscles surrounding the affected joint are paralysed a fixed deformity results, which is caused not only by gravity but also by muscular action. If the weight acts in the same direction as the action of the intact muscles, the deformity always becomes fixed in this direction. But if the weight acts in an opposite direction to the line of action of the muscles, sometimes the weight and sometimes the muscular action preponderates, and thus the direction of the deformity is influenced according to the existing mechanical conditions. If the part of the body concerned is not subjected to weight, or at

least only very slightly so—as, for instance, the eye and the soft parts of the face—then the deformity is effected only by the action of the intact muscles. This muscular contraction is nevertheless not to be regarded as spastic or tonic. It depends much more upon the muscles having the power of actively shortening but not of actually lengthening. If the muscular contraction ceases the muscle becomes rigid in the same position which it occupied at the moment of the strongest contraction, unless it is stretched by the action of the antagonistic muscles or by weight. If both factors are absent—as, for instance, in the case of the eye, in paralysis of the abducens nerve, and in the face with paralysis of the facial nerve—then such lengthening does not take place, and the muscle remains permanently contracted. In consequence of the persistent approximation of the points of attachment of the muscles, the connective tissue covering of the muscular fibres accommodates itself to this shortened length, and the contraction passes into 'nutritive' shortening. Whilst at first the contraction may be rectified by slight counter-extension, and at a later date may still be effected under chloroform, it can finally be no longer accomplished even in deep anæsthesia.

The shortening is now no longer maintained by the contraction of the muscular fibres themselves, but by the shrinking of the connective tissue surrounding them. The original muscular contraction, which later became muscular contracture, has now been superseded by contraction of the connective tissue. The celebrated theory of 'antagonism' which was advanced some time ago to explain all paralytic deformities, was in error in only taking into consideration the action and counteraction of the antagonistically arranged muscles, while it completely overlooked the factor 'weight,' which in these cases plays so great a part in the process. The reaction, chiefly due to Hueter and Volkmann, in opposition to the one-sidedness of this theory, fell into the opposite extreme by taking only weight into consideration, and endeavouring to eliminate muscular action entirely. Both theories were insufficient for the explanation of the facts. Only by the consideration of both muscular action and weight can we explain clearly all the complicated conditions of paralytic deformities.

The disease which most frequently gives rise to paralytic deformities is spinal paralysis of childhood, which chiefly affects the lower extremities, and most frequently the feet. A very much less frequent cause is tubercular meningitis, or cerebro-spinal meningitis, which produces deformities partly by disabling separate groups of muscles by paralysis, partly by causing genuine spastic contraction in others, which afterwards may be transformed into permanent shortening. Division or contusion of peripheral nerves from injury also may cause severe paralytic deformities.

The treatment of paralysis falls entirely into the domain of neuro-pathology. Orthopædic surgery has only to deal with rectifying the deformities which the paralysis has produced. To endeavour to stretch the retracted muscles by passive movement is useless; they withstand such action in the most obstinate manner. Nothing remains but to cut their tendons, and it is in the case of paralytic deformities that subcutaneous tenotomy is most successful.

After division of the tendons of the shortened muscles, the resistances to the restoration of the joint to its normal position is removed, unless (which seldom, however, happens in paralytic deformities) contraction of the ligaments, adhesions of the articular surfaces, or changes in the form of the bones have taken place. Nevertheless it is as well not to place the affected joint in the desired position at once, but to leave it in the deformed position for the first three days, and then to undertake the rectification gradually.

This plan favours the healing of the wound caused by the division of the tendons, whilst immediate rectification may by means of the separation of the cut surfaces prevent their joining properly. The desired position may be thus attained, but the joint will be wanting in the requisite firmness to be an adequate support for the body.[1]

[1] My experience is very much in favour of immediate rectification by placing the joint in the desired position, or nearly in this position, at once. If this plan is followed the newly formed tendon will more completely restore the deficiency of length, and there is little or no risk of recontraction, a not uncommon result of the process described above. If this course is followed the parts must be left for a week undisturbed. The sub-

The manner of healing of the tenotomy wound is not yet perfectly understood. There are two theories on the subject, which may be described as—(1) the theory of linear cicatrix and (2) the theory of interposed connective tissue. Stromeyer and Dieffenbach, who have been followed by the majority of later authors, were advocates of the first theory. This may be described as follows:—After the muscle has lost all tension in consequence of the division of its tendon, it becomes completely relaxed. Now if we allow the tendon wound to unite by first intention, which happens within three days, and then perform a slow stretching, it is possible to extend the relaxed muscle considerably beyond its original length. After complete cure, the tendon cicatrix forms a fine white line, and the lengthening is due to the fact that the muscular substance has lost its previous rigidity and is now amenable to stretching influences. The linear theory took a somewhat different form, according to the views of Tamplin, Brodhurst, and Holmes-Coote. These authors taught that, during the first three days during which tendon wounds are left in repose after subcutaneous tenotomy, union takes place by means of new cicatricial tissue. Now, in the same proportion in which later on the divided tendon ends are separated from one another by extension, this newly formed uniting tissue extends. But since this is nothing but cicatricial tissue, it possesses a disposition to contraction, and consequently draws the ends gradually more and more together; until it effects the closure of the divided tendon ends in a linear union, whilst the muscular substance lengthens under the influence of this gradual retraction in the same relation as the intermediate substance shortens. In opposition to this view, two of the orthopædic surgeons most eminent for the care and point of their observations, Bouvier[1] and W. Adams,[2] advanced the theory of the interposed tissue formation. Both authors ascribe to the sheath of the tendon a large part in the forma-

sequent treatment is much less troublesome and tedious than the process of stretching out a short cicatrix. Of course, discretion must be exercised not to separate the ends too far, and care must be taken not to press upon the gap between the ends with the bandage after operation.—N. S.

[1] Bouvier, *Leçons cliniques sur les maladies chroniques de l'appareil locomoteur*. Paris, 1858.

[2] W. Adams, *On the Reparative Process of Human Tendons*. London, 1860.

tion of this tissue. The divided tendon ends separate from one another, but the tendon sheath embraces both and bridges over the gaping fissure at the site of the tenotomy. Now from the tendon sheath a new, firm, uniting band is formed, which subsequently acts as true tendon. Adams therefore calls the tendon sheath the *matrix* of the newly formed tissue. This opinion cannot, however, be adopted in its entirety. The tendon sheath would be a matrix for tendon substance if it contained upon its inner surface a layer of cells, which possessed the special power of forming tendon tissue, as the periosteum is a matrix for bone tissue, because it has on its inner surface a layer of bone-forming cells (osteoblasts). The tendon sheath, however, is possessed of no such layer of cells. Therefore I regard the enclosing sheath certainly not as the matrix of the new formation, but rather as a moulding membrane. Its continuity, bridging over the gaping ends of tendon, gives form to the inflammatory tissue formation, which appears at the place of division; it conducts the developing cicatricial tissue towards the two divided tendon ends, and thus effects the union at the right place. The interposed portion of newly formed tissue is thus nothing more than ordinary cicatricial tissue, and not tendon substance in a proper sense, as Bouvier plainly states; and although Adams explains himself more reservedly with reference to this, even he insists that the interposed tissue is clearly marked out from the old tendon substance, and consequently may be accurately recognised and measured even years afterwards in its full extent, in a longitudinal section of the tendon, by its paler colour, even when viewed by the naked eye.

In my opinion this last theory is undoubtedly the right one in all those cases in which the muscular contracture has already passed into 'nutritive' shortening and connective tissue retraction. A muscular substance which allows itself to be extended to its original length is here no longer present; the shortening is no longer maintained by muscular contraction, but by cicatricial connective tissue.

On the other hand, I believe that for contractures of a more recent date, in which a real muscular contraction is still present, the theory of the linear cicatrix is the correct one. It

is, as Stromeyer has already remarked, especially difficult to assume, in the case of a shortened sterno-cleido-mastoid, that the lengthening produced by tenotomy is caused by the interposition of fibrous connective tissue, for the shortening here is often so considerable, that after its removal by tenotomy the half of the lengthening of the muscle would consist of this intercalated connective tissue, which can hardly be the case. On the contrary, in tenotomy of the Achilles tendon, on account of retraction of the gastrocnemius, there can be no question that the lengthening is caused by the intercalation of a new piece of tissue, for one finds in these cases a clear retraction of the muscular belly of the gastrocnemius, an appearance which has been referred to by many authors in support of the above view. The different views in regard to the above two theories may be therefore reconciled thus: that in cases of recent muscular contractures, tenotomy produces the lengthening of the muscle by the stretching of the substance with linear cicatrix; on the other hand, in all cases of longer duration, in which connective tissue retraction predominates, it is by means of intercalation of new tissue between the divided tendon ends.

When the healing of the tendon wound is perfectly completed—a result which is generally effected in about six weeks—it is possible by means of passive movements (and in cases in which the paralysis has disappeared, so that voluntary action of the muscles may take place, also by active movements) to exercise the joint, in order to restore to the articular surfaces their normal smoothness, and to the ligaments their requisite elasticity. If the exercises, from which, under such circumstances, there is no danger of setting up inflammation, are continued with the necessary perseverance, the joint may in time become almost as useful as a normal joint. This is especially true of the ankle joint, which most frequently suffers from paralytic deformities. The treatment of talipes equinus, and to a certain extent of paralytic talipes equino-varus, belongs, therefore, to the most satisfactory of all surgical undertakings. At the knee-joint paralytic deformities occur less often, and their cure presents much greater difficulties. We must in this case take special care in performing tenotomy of the biceps tendon not to divide the peroneal nerve, which is in close proximity

to it—a mistake which was often committed in earlier times, when this tenotomy was much more frequently practised than it is at the present day. Now, as in subcutaneous operation avoidance of this nerve is not certain, we shall do best to expose the tendon by free incision under the protection of antiseptics, and to divide the tendon apart from the nerve under the guidance of the eye. The small wound, stitched up, will heal in a few days under an antiseptic dressing.

The subcutaneous principle of operation, which formerly so powerfully supported tenotomy, has lost much of its importance since the introduction of antiseptics, as we can now, with their help, perform operations with open incision, for the healing of which the subcutaneous method was previously indispensable. At the hip joint the adductors are the only muscles which may require division, and this happens when the leg is strongly adducted, and when attempts at replacement cause the attachments of these muscles to the pelvis to become very tense. After careful cleansing of the skin, the tenotome should be inserted and passed into the subcutaneous connective tissue, the cutting edge turned towards the muscle, and the latter cut from without inwards, as much of the fibres being divided as is necessary to overcome the resistance. Injury to neighbouring structures need not be feared. Division of the tendon of the psoas and iliacus muscles in flexion contracture is now, desirable as it often may be, scarcely ever performed, because access to these tendons is beset with danger in consequence of the close proximity of large vessels and the crural nerve.

The fourth and last group of deformities of the lower extremities consists of those caused by **primary abnormal bone-growth.** This expression requires an explanation. It is self-evident that this abnormal bone-growth, although we call it primary, must have an origin, and therefore it must be produced by some preceding cause. Therefore, when we call it primary, it is only meant to express that it is caused by some other influences than those mentioned, *i.e.* neither by weight, articular inflammation, nor paralysis. These other causes can only consist in an early bony coalescence of the epiphysis with the diaphysis. If this occurs before the normal time, the bone ceases to grow. If the portion of the limb in which this occurs

has but one bone, the only deformity which results is that the limb does not attain its normal length. This may, however, occasion a serious deformity, as, for example, when an early ossification occurs of the lower epiphysial line of the femur (a bone which is endowed with a very great power of growth); for the thigh, and consequently the whole leg, remains shorter than the other, and the patient is therefore (when the deformity is not sufficiently slight to be overcome by a tilting of the pelvis) obliged to walk lame, or else wear a high sole in compensation.

The conditions are, however, very much more complicated when the portion of limb affected has two bones, one of which only suffers from the premature interruption to growth. For example, if the tibia be affected while the fibula continues growing, the foot is pushed into the varus position; while if the growth of the tibia continues and that of the fibula ceases, the foot is forced into the valgus position. But the conditions are still more complicated when several bones are united in a girdle, as, for example, at the pelvis. As we are entitled at the present stage of the question of bone-growth to exclude completely the consideration of interstitial growth, we may state that the widening of the pelvic girdle is effected at five places of apposition: the symphysis pubis, both sacro-iliac synchondroses, and both Y-shaped cartilages which join together the ilium, pubes, and ischium in youth, the latter of which ossify at the time of puberty, whilst the first three places remain cartilaginous (under normal conditions) during the whole of life. If, during the period of bone-growth, an osseous union occurs at one of these places, all further growth is in consequence stopped at the place affected. A premature ossification of the Y-shaped cartilage, which is not infrequently produced by coxitis in childhood, does not, however, appear to disturb greatly the growth of the pelvic girdle, for we often find a pelvis of the normal width in cases in which the clearest signs of a severe coxitis having occurred in childhood are present. Probably a compensating increased bone-formation in both symphyses has occurred in these cases. An ossification of the symphysis pubis at the time of bone-growth would cause a retardation of the widening of the pelvic girdle without disturbing the symmetry of the two halves, but such a condition has never hitherto been observed.

On the other hand, from the researches of Nägele,[1] the coalescence of the sacro-iliac symphysis upon one side with its deforming influence upon the form of the pelvic girdle, is very well known as occurring in youth. In the typical obliquely contracted pelvis described by Nägele there is complete coalescence of the sacrum with one ilium, deficient development of the affected lateral half of the sacrum, and narrowing of the anterior sacral foramina on the side on which the ankylosis is found. As a result of this condition, a considerable want of symmetry of the pelvic aperture is produced. Whilst the ankylosed half of the pelvis is retarded in growth, the opposite half is, on the contrary, much developed, and the symphysis pubis considerably encroaches from the sound side, beyond the middle line. The long diameter of the oval, which the pelvic aperture now forms, runs from the ankylosed symphysis to the opposite acetabulum ; the short diameter is at right angles to this. This form of ankylosis appears to depend upon a fault in formation, as testified by the total ossification of the symphysis without any apparent thickening of the bone, the defective development of the sacral half in question, and the smallness of the anterior sacral foramina, as well as the fact that in those cases in which an accurate history has been obtained not the slightest symptom was recorded of the occurrence of inflammation in earlier years. On the other hand, cases have been known in which a distinctly perceptible inflammation has produced the bony coalescence of the symphysis ; but in these cases the sacrum was symmetrically formed, and the asymmetry of the pelvic girdle was proportionately less.

Besides retarded bone-growth, accelerated growth may also give rise to deformity. Here the same result occurs as before, in a reversed manner. The processes which cause either retardation or acceleration of growth are generally inflammations, which we designate, according to the parts chiefly affected, by the names of ostitis, periostitis, or osteomyelitis. These inflammations are now generally considered as infectious diseases, for the localisation of which in any particular place the contusions, shocks, chills, &c., which frequently precede the attacks are to be held responsible. On account of these trifling accidental

[1] F. C. Nägele, *Das schräg verengte Becken.* Mainz, 1839.

causes these inflammations are often called spontaneous, and since, with very few exceptions, they only occur in growing bones, their full name is the spontaneous inflammation of bone in youth (infectious or pseudo-rheumatic, according to Roser). Ollier has discovered the law which governs the influence of these inflammations upon bone-growth, and it is as follows.

If the inflammation has its seat in the diaphysis of the growing bone, its effect is almost always an acceleration of growth; whereas, if its seat is in the epiphysis or in the part of the diaphysis near to the epiphysial cartilaginous disc, the effect is generally retardation of bone-growth. Acceleration of growth when the diaphysis is affected is explained by the great increase in the quantity of blood which flows to the diseased bone, as well as by the conduction of the inflammatory irritation to the epiphysial cartilage, causing greater activity in the part. The retardation of growth which occurs when the inflammation is in the immediate neighbourhood of the epiphysial line, is caused by the cartilaginous disc itself being either destroyed, as shown in the frequent inflammatory separations of the epiphysis from the diaphysis, or at least by its being too much deranged in structure to be able to display the normal energy of growth. After cessation of the inflammation, the bony coalescence between epiphysis and diaphysis is often then completed. Besides this most frequent cause of premature epiphysial ossification, there are also cases in which neither the symptoms during life nor the appearance after death give the slightest reason for supposing that the ossification is the consequence of inflammation. This is especially shown, as already mentioned, in the obliquely contracted pelvis. In such cases we are obliged to seek for other causes, and of these the most probable is an anomalous formation, owing to which the bony centres normally separated are primarily joined together.

Treatment is out of the question in this class of deformity. A bone with an ossified epiphysial line does not grow, whatever we may do to it, so that even the irritation produced by the driving in of ivory pegs, as sometimes proposed, is ineffective. In quickened growth we may resolve to cut a cartilaginous disc out of the epiphysial line of the too quickly growing bone, and thus retard further development at this place. An obliquely

narrowed pelvis is generally discovered at the time of parturition by the hindrance it presents to the passage of the fœtus. Orthopædic treatment is out of the question, even if this evil were recognised at the time of its development.

To this group also belong a number of deformities, which are certainly not caused by primary abnormal growth, but rather by primary proliferation and absorption processes of the osseous tissue. These are the deformities caused by **chronic articular rheumatism, arthritis deformans**, and **gout.** The expression 'primary' has here the same meaning as before stated, *i.e.* it is applied to the above processes, as the causes of the deformities, although they are themselves induced by the fundamental changes, hitherto but little known, underlying these diseases.

Chronic articular rheumatism, after existing a long time, very frequently leads to outgrowths of the joint cartilage, which in these places and in other parts is destroyed, exposing the bony surface beneath. The fibrous tissues, joint capsules, and supporting ligaments shrink, and thus hinder, first, the range of movement of the joint, and, later on, fix it in a definite and generally very abnormal position. The bone surfaces themselves coalesce by connective-tissue cicatricial adhesions, which may give place later on to complete bony ankylosis, or they may be unalterably united by processes proceeding from one bone to the other, following the course of the articular capsule.

Arthritis deformans is chiefly distinguished from articular rheumatism by the fact that it never produces bony ankylosis in the joints affected by it (as occurs so very often in the rheumatic affection), and further also by a much greater degree of bony absorption than in that disease. Peripheral growth with central atrophy characterises the course of *arthritic joint-diseases.* In this manner the well-known fungous-shaped joint-heads are produced which are so peculiar to this disease. The hip joint is most frequently affected. The disease was first noticed in this joint, and was described by the name *Malum coxæ senile.* The absorption may be so great in these cases that the whole head and neck of the femur may waste away, and the acetabulum (also very much deformed) may articulate direct with the trochanter. But, besides the hip joint,

the other large as well as small joints are not infrequently affected, and they may suffer similar deformities. The treatment of these diseases is beset with great difficulties. In chronic joint rheumatism we are sometimes able, by such means as hot baths, hot sulphur springs, cold water applications, iodide of potassium, salicylic acid, and colchicum, to modify their course favourably, although relapses frequently follow such improvements. With arthritis deformans, on the other hand, all treatment has hitherto proved totally ineffectual. Local treatment of a single diseased joint, by systematic active and passive movements, and massage, where possible, with the addition of warm spray or vapour douches, may preserve mobility for a considerable time, and may be of very great advantage in this respect; but such treatment is powerless to stop the course of these diseases or to hinder ankyloses and deformities when there is much predisposition to them. It is always well to contend against contraction and ankylosis by systematic movements as long as possible.

Gout (*Arthritis urica*) exhibits, as a characteristic symptom, uric acid deposits on articular surfaces. This effect is not necessarily connected with bone-growth. The articular surfaces may be covered with uric acid deposit, and yet in their form may differ in no way from the normal. Generally, however, the growths are associated with the deposition of uric acid crystals, and the joint ends may thus acquire a knobby, enlarged form, causing alterations in position. The best known, however, are the displacements of the finger joints caused by gouty deposits. The problem for treatment is to combat by general means the original disease, and to oppose the local deformity by systematic movements (as much as the patients can bear), in order to preserve mobility.

The deformities of the *upper extremities* are similar in many respects to those of the lower, yet there exists between the two an important difference, which is, that the upper, as they are not used for the support and movement of the body, are almost completely free from the effects of pressure, which plays so large a part in the development of deformities of the lower limbs. The arm, however, when it temporarily supports

the body or raises a weight perpendicularly, may be deformed by pressure ; such cases, however, are but rare exceptions. Weight, moreover, acts upon the arm in an opposite direction to its action on the leg. Whilst it produces upon the latter a pressing together of the bone, and consequently tends to shorten, it inclines to stretch and lengthen the former. Through this difference weight may produce deformities in the arm which are exactly contrary to those in the leg. For example, it not infrequently happens that in the course of inflammation of the shoulder joint with atrophy of the surrounding muscles, or paralysis of the deltoid muscle, the head of the humerus sinks, so that separation takes place between it and the articular cavity of the scapula. Weight here does not compress but draws asunder. Naturally the deformity is not one of fixation: as soon as the arm is raised by extraneous external agency, the head of the humerus again rises into contact with the articular cavity. Special weight deformities analogous to talipes valgus and genu valgum do not occur in the upper extremities. Deformities of the bones in consequence of rickets and osteomalacia appear also in the upper extremities, although considerably less often than in the lower, but muscular contraction plays a much greater part in their origin than does weight. The removal of these deformities is effected by the same means as have been described above; the resistance, however, is much less, so that the bones yield much more easily to pressure, to bending, and even to subcutaneous fracture, and therefore it is only exceptionally that they need the employment of osteotomy.

The deformities produced by joint inflammations of the upper much resemble those of the lower extremities, and require essentially the same treatment. In acute inflammation, rest is the most important part of the treatment, since separation of the joint surfaces can only be accomplished with difficulty, except in the shoulder joint, in which the dependency of the arm already effects separation, and still more when its weight is increased by a plaster bandage. The most favourable positions for eventual ankylosis are—for the shoulder joint, the vertical position of the arm ; for the elbow joint, the right angle ; and for the wrist, the straight median position. If acute inflammation has ceased, it is necessary to restore the greatest possible move-

ment by active and passive exercises; nevertheless we here meet with the same difficulties and hindrances as in the lower extremities. At the shoulder joint it is especially the elevation of the arm to the perpendicular, which power is very easily lost in inflammation of this joint. Elevation, as is well known, is only partly effected in the shoulder joint proper, and only as far as a right angle to the body; the rest is produced by rotation of the scapula and elevation of the clavicle.

In every inflammation of the shoulder joint both parts of the elevation movement suffer, and generally it is not possible to remove the arm further than 45° from the side of the body. By great perseverance of passive movement it is possible, tolerably often, to increase the elevation to the right angle, but I have never seen anyone succeed in attaining elevation to the perpendicular after inflammation of this joint. I therefore consider this movement in its full extent as irreparably lost in inflammation of the shoulder joint, and have always advised patients belonging to the working classes who are thus affected to seek an employment in which the elevation of the arm is not required. The hindrance to free elevation depends partly upon connective-tissue adhesions of the articular surfaces as well as upon the shrinking of the capsule and ligaments, but to a great extent also upon cicatricial contraction of the muscles extending from the thorax to the humerus, especially of the pectoralis major and latissimus dorsi. In the case of the elbow-joint as much attention must be paid to flexion and extension as to pronation and supination, and we may by sufficient perseverance restore free mobility to this joint. The movements of the wrist are of great mechanical importance, although not quite so important as those of the fingers. A man with a wrist ankylosed in the middle position, and with the fingers free, may still possess considerably capacity for work. I know a gentleman who suffered from bony ankylosis after suppuration of the wrist, which had produced a solid continuous connection between the forearm and the metacarpal bones, and who is able by means of the free movement of his fingers to hold the reins so firmly that he is one of the first drivers on the 'track.' We must therefore take the greatest care to preserve the mobility of the wrist, but still more that of the fingers, as it is

the latter upon which the hand depends chiefly for its mechanical capabilities.

The **deformities of the fingers** which are caused by joint inflammations and cicatrices are of great importance. Of the former it is especially the fungous or, as they are now commonly called, tuberculous inflammations of the bones and joints which have come under consideration. These have generally their seat in the medullary portion of the phalanges, and if severe may cause a spindle-shaped thickening of the bone, from which form this disease has been named *spina ventosa*. From their original seat these inflammations may extend to the joints, or even, though less often, originate in the synovial membrane. Deformities may arise, either at the time of active inflammation from enlargement of the bone, or after inflammation from cicatricial contraction. The treatment of this disease is either expective—that is, while using the ordinary anti-scrofulous remedies, we await a cure, which generally happens in the course of a few years with the disappearance of the scrofulous conditions—or it is more active, and consists in making an incision at the time of the swelling into the softened bone, taking away the fungous granulations from the medullary cavity with a small sharp scoop, and filling the cavity with iodoform. The first is the more tedious treatment, but generally ends in a more satisfactory result as to functional restoration than the last. If deformities threaten we must guard against them by binding the fingers to a supporting splint. Cicatricial formations very often occur upon the hands and fingers. The most frequent are the cicatrices caused by wounds and burns, to which the fingers are especially subject on account of their exposed position.

The treatment of these cases should be at the time when the wounds or burns are fresh, to oppose the development of deformities, chiefly by means of antiseptic applications, which secure healing without suppuration, and therefore leave much less cicatricial tissue; also by bandaging to splints in the most favourable position possible until the wound heals; subsequently, the use of passive movements, to procure good mobility of the joints. Abscesses also, which occur so often in consequence of infection of small incised or punctured wounds, often produce severe deformities from cicatricial contraction.

Early incision, energetic disinfection of the wound, careful drainage, and good fixation in antiseptic dressings are the means by which we guard against a deforming cicatrix. But even this treatment, which certainly secures much better results than the earlier one attended with suppuration, does not ensure an absence of deformity. In the one case, cicatrices of the skin, fascia, and ligaments are to be feared; and, in the other, the coalescence of the tendons with one another, with their sheaths, or even with the bone.

If, as so often happens, necrosis of a tendon occurs in the course of the inflammation, then the movement effected by such tendon is irretrievably lost. As it is almost invariably the long flexor tendon which is concerned, the finger then assumes a position either of semi-flexion from shrinking of the cicatrised skin, or it remains under the unopposed influence of the tendon fixed in complete extension. The last condition is even worse than the first, since this position exposes the finger to further injuries, and interferes very much with the use of the hand. Also, after incisions for paronychia, after severe contusions, and especially after section of the median nerve, the condition may occur which is called 'glossy finger.' The skin loses its normal pliability and becomes smooth, shining, and by its want of flexibility interferes with all movement. It coalesces with the subcutaneous connective tissue, the fascia, tendons, and even with the periosteum, to form a homogeneous, cicatricial mass, and thus fixes the finger in one position.

But there is also in the hand a special kind of cicatricial contraction which we call, after its first observer, **Dupuytren's contraction**,[1] of the palmar-aponeurosis. After long continuance of frequently repeated pressure, as, for example, with joiners who use the chisel, or with people who are employed in stamping letters, and thus press the knob of the stamp against the hollow of the hand, &c., after considerable overstraining of the fingers in *hyper-extension*, or even without any visible injury, there is formed in the course of years a progressive flexion of the fingers. To a certain extent this bent position is to be found in all workers who have to perform heavy manual labour. The fingers can be no longer extended into a straight line with the meta-

[1] Dupuytren, *Leçons orales*, vol. iv. p. 482.

carpal bones, and are therefore always more or less flexed. In Dupuytren's finger-contraction proper, however, a sharply defined cicatricial band stands out in the palm when an attempt is made to stretch the fingers, which resists further stretching most obstinately; the fourth finger is by far the most frequently affected by this contracture, and, after that, the fifth. It is only after the affection has existed a very long time that the third finger ever becomes involved, and after that the second finger may be attacked, but it is very rare indeed for the thumb to suffer. In the course of time the flexed position becomes still more strongly marked, so that finally the finger-nails may produce an indentation in the hollow of the hand. Dupuytren localised this shrinking in the palmar-aponeurosis; Malgaigne,[1] on the other hand, in the skin and subcutaneous connective tissue; but this difference is of no great importance, for in the course of time skin, subcutaneous connective tissue, and aponeurosis coalesce into an indivisible cicatricial tissue, which forms by its shortening the projecting band.[2] The tendons do not blend with this cicatricial mass, but lie deeper from the surface unaffected. Thus they play no primary part in this contraction. As, however, they are placed in a shortened position through the cicatricial contraction, they, or rather the muscles belonging to them, also become shortened, so that in the older and more severe cases we cannot produce extension even after complete division of the cicatricial mass, because of the resistance of the flexor tendons.

Finally, there is a form of cicatricial contraction of the hand which is the consequence of tight constriction in the neighbourhood of the wrist. Any constriction of this part may be the cause of the contraction, which shows itself under the form of the claw hand (*main en griffe*), the principal characteristics of which consist in hyper-extension of the proximal phalanges with flexion of the terminal phalanges. This deformity arises most often when, on account of fracture of the epiphysis of the radius, an insufficiently padded plaster

[1] Malgaigne, *Leçons d'orthopédie*, p. 7. Paris, 1862.

[2] However, the fact that upon subcutaneous division of the fascia the skin is released, either completely or to a great extent, proves that the latter is not commonly involved structurally.—N. S.

bandage has been applied in the neighbourhood of the wrist. The bones are here only covered by tendons and skin, and every swelling which cannot take place freely, from the non-elasticity of the plaster bandage, immediately gives rise to serious disturbances of the circulation. When such a bandage remains on for from twelve to twenty-four hours, or even for a shorter time, the contraction may occur, and the usefulness of the hand be destroyed. It is therefore of the greatest importance that a thick padding should be used with every wrist bandage, after reduction of dislocation in fracture of the lower epiphysis of the radius, and especially when plaster or other stiff bandages are used, because in these cases there is greater danger of constriction. These contractions used to be attributed to pressure on a nerve, especially the ulnar: Volkmann[1] is undoubtedly right, when he, in opposition to this theory, attributes them to ischæmic muscular shortening. It is not the pressure upon the nerves that causes the paralysis which produces the contracture, but it is the continued deprivation of blood which induces contraction in the muscular and fibrous tissues. A paralytic contraction could not establish itself as quickly as these often do completely, in a few days. All the fibrous and muscular structures of the hand take part in this contraction, which fact explains the great firmness of the parts. When the constriction of the bandage is not so tight the consequences are less. Obstinate chronic œdema, and stiffness of the tendons and ligaments, hindering freedom of the finger-movements, are then the most prominent symptoms. The treatment of cicatricial formations is always difficult. These formations are generally not extensible, either by continued elastic traction, or by force while the patient is under the influence of an anæsthetic. The first is resisted by the cicatricial tissue, and in the latter this tissue, together with the skin covering it, is torn open, so that we must allow the wound to cicatrise again before interference, a proceeding which renders the partially attained success nugatory.

Sometimes warm baths, especially with soap, soda, potash, &c., natural hot and sulphur springs, mud baths, or, finally,

[1] Volkmann, *Centralblatt für Chirurgie*, 1881, No. 51.

animal baths,[1] handed down to us from antiquity, with careful and persevering passive movements at the same time, avail to lessen the contracture, and to restore some increased mobility; but these means often fail. Severe and tough scars in the hand oppose very great resistance to all attempts at stretching. Operative treatment of cicatricial contractions must consist essentially either in subcutaneous division or in a plastic operation. Subcutaneous division is in most of these cases not practicable, because the skin has so inseparably coalesced with the cicatrix that an isolated division is impossible. Either cicatricial bands remain or the skin is cut through; in either case the result is but small. A plastic operation may be performed, either by altering the position of the skin or by transplanting a stalked flap. In altering the position of the skin, a V-shaped incision is made through the skin at the site of the projecting band, then the cicatricial cord is thoroughly divided, and the skin brought together so that it takes the form of a Y. This procedure appears very well on paper, but is quite powerless to overcome a severe cicatricial contraction, for in a very short time the old condition returns. The second kind of plastic operation is the division of the cicatrix, and transplantation, or engrafting, of a stalked flap of skin into the cleft. This method may, in the face, especially in the eyelids and lips, produce good results, always supposing that a sufficient quantity of healthy skin is present in the neighbourhood; but in the hand it is quite ineffective, as the skin of the extremities is in no way available. There are, therefore, no special means which are of much avail against these cicatricial contractions. A careful choice and prudent combination of methods may, on the other hand, often produce results in such cases which are worth consideration, and which at least restore some degree of usefulness to the hand.

For the cure of flexion contractions, the result of *paronychia*, Schönborn has invented a very effective extension

[1] Animal baths are either taken by placing the hand in the peritoneal cavity of a newly killed animal, or in the recently removed stomach of an ox, or, finally, and most simply, in the manner generally pursued in the country, of laying freshly deposited cow-dung upon the extremity. The hand remains in until cold.

machine with elastic power ('Langenb. Arch.,' vol. xii. p. 371, 1871), and has used it in a severe case with great energy, but without much result. Again, Beely has invented an extension apparatus, which is used as follows. The forearm is laid upon a board rather longer than itself; the elbow is fixed to it by a bandage; a loop of American sticking plaster (*i.e.* gutta-percha spread upon linen) is fastened to the affected finger, and fixed with circular bands of the same plaster; through the loop an elastic band is passed which is fixed to the board in a state of continual tension. The patient wears the whole apparatus in a sling, and walks about freely. At night he lays the arm which is fixed to the board upon a cushion. The extension of the india-rubber band is altered according to the tolerance of the patient. The apparatus is an ingenious one, and ought undoubtedly to be tried in suitable cases, but whether permanent results can be attained by it can only be learnt by longer experience. Sklerodermic processes resist all treatment.

Dupuytren's finger-contraction is best left without treatment in cases where it is confined to the third and fourth fingers, and when it occurs with people who do not require to use their hands for very severe work, as it does not cause much annoyance, and only increases very slowly. If the use of the hand, however, is much interfered with by it, one of the above described extension methods should first be tried with the object of producing extension without making a wound. If this fails, which is usually the case, a cutting operation, such as subcutaneous division of the cicatrix, or a plastic transplantation must be resorted to, when sometimes a favourable result may ensue. If these measures also fail, then it only remains to overcome the difficulty by the removal of those fingers which most severely oppose the function of the hand by their flexed position. A case lately observed by me may serve as an example.

Otto Rex (aged 41), a gardener, who had always enjoyed good health, had suffered for fourteen years from a severe hyper-extension of the fourth finger of the left hand. This, at first, caused only a little inconvenience; gradually, however, a flexion contraction of this finger developed, which spread to the fifth finger. As the patient could still move the three principal fingers freely, he could exercise

his calling tolerably well. Subsequently, however, the third finger began to be flexed, which made it impossible for the patient to bind up bast threads. The thumb and index finger were still free. Discouraged by previous unsuccessful treatment, the patient desired removal of the fourth finger. Under chloroform, extension of the fourth finger by force was attempted. This somewhat improved the position, but the skin at the folds of the interphalangeal joints was torn, and in consequence the extension had to be given up. A longitudinal incision was then made over the prominent cicatricial band, and after its transverse division extension was increased, but yet was not complete. Then the tendon sheaths of the flexors were laid bare, and the tendon of the flexor sublimis divided, which allowed still further extension.[1] Upon this followed the division of the tendon of the flexor profundus, with again a slight diminution of the position of flexion. As, however, considerable contraction still existed, the finger was finally removed.

Whether it is possible, by early removal of the fourth finger, to prevent the extension of the cicatricial contraction to the other fingers has not yet been determined by observation.

The cure of *ischæmic claw-hand* is impossible after it has existed a long time; stretching is useless, and divisions lead to irregular coalescence of the tendons without improvement to function. In quite recent *ischæmic* contractions, Volkmann recommends stretching the shortened rigid muscles under chloroform, by the application of even the most extreme force. Continued passive movements may then restore a certain degree of usefulness. Even the slighter degrees of disturbances of the circulation which are produced by tight bandaging, as expressed in œdema and obstinate stiffness in movements, require long-continued treatment by baths and passive exercises, and then the result is often only a partial success.[2]

The third group of deformities of the upper extremities are the paralytic. *Paralysis of the ulnar nerve*, a common occurrence after division of this nerve in the neighbourhood of the wrist, or from pressure and injury at the place where the nerve lies against the internal condyle of the humerus, only covered by skin, brings on a severe deformity of the hand, which shows

[1] This history seems hardly that of a pure case of Dupuytren's contraction, in which the tendons are, as a rule, unaffected.—N. S.

[2] See the *Surgery of Deformities*, by E. Noble Smith, p. 140.

itself under the form of the *main en griffe*. It is in this case the suspended function of the interossei muscles which causes the deformity. The action of these muscles consists, as Duchenne was the first to point out, in the bending of the first phalanges with simultaneous extension of the two distal phalanges. If this action fails, the fingers are placed under the exclusive influence of the long flexor and of the extensor muscles in the opposite position—hyper-extension of the first phalanx with flexion of the second and third phalanges, and this is the characteristic position of the *main en griffe*. In this case the disturbed muscular equilibrium only is concerned, as there is here not much weight influence. Surgical interference is not applicable to these cases, but Duchenne asserts that local faradisation of the interossei may considerably lessen the deformity even after many years, and in the most favourable cases may remove it completely. Paralysis of the radial nerve, generally caused by injury or division of this nerve where it crosses the outer border of the humerus, or by disease, such as lead paralysis, causes the dropping of the hand at the wrist joint from paralysis of the extensors and supinators. *Wrist-drop* is the characteristic English expression for this condition. Although weight and muscular power act in the same direction, yet this deformity does not become perfectly fixed even after many years. We can almost always raise the hand to a straight line with the forearm without using much strength, but the shortened flexors resist further movement into hyper-extension. Here there is nothing to be hoped for from gymnastic treatment. If, by means of electricity or by freeing the nerve from any pressure of connective tissue or bony callus, we succeed in removing the paralysis, then the normal position of the hand is speedily regained, and this result may be hastened by passive and (as soon as the muscles are again obedient to the will) by active movements. Paralysis of the median nerve, in consequence of its division at the wrist, causes atrophy of the muscles of the ball of the thumb, with the exception of the adductor muscle (supplied by the ulnar nerve), without, however, inducing much deformity. Higher up the arm the median nerve is seldom injured, in consequence of its protected position, and even if its function is interrupted here—as, for instance, by the

pressure of a tumour—although the pronators and most of the flexors will be paralysed, yet no special deformity will be produced. In the elbow and shoulder joints marked paralytic deformities seldom occur, and the treatment of these cases belongs exclusively to neuropathology. In consequence of central nerve diseases, especially apoplexy, fixed deformities of the upper extremities often appear, which are generally brought on by muscular action, with only a slight influence from weight. If the general condition of the patient admits of local treatment, we must endeavour by electricity, passive movements, and massage to oppose the development of these deformities.

Primary abnormal growth of bone produces in the upper extremities disturbances which are quite similar to those in the lower, though here the conditions are more favourable, in so far as unequal length of the upper arm causes no hindrance to the performance of the functions of the limb. Unequal growth of the radius and ulna, however, produces oblique position of the hand, with very considerable functional disturbance. The treatment of this condition at the time of bone-growth consists in cutting out a piece of the very easily accessible cartilaginous epiphysial line of the bone which is too long, and thus retarding the growth at this place—that is, exclusively from the lower epiphysis, which always develops a much greater intensity of growth than the upper. If the other bone increases more rapidly in proportion, the deformity may be rectified in the course of years. Ollier,[1] in this manner, so far restored the arm in a man, aged 20 (whose hand, in consequence of retarded growth of the radius, caused by former ostitis, had become drawn to the radial side), by excision of a piece from the lower epiphysial line of the ulna, so that in the course of five years the hand returned to its normal position. If, on the other hand, the bone-growth has completely ceased, then by excision of a piece from the bone which is too long the equality in length may be restored.

The deformities caused by gout, arthritis deformans, and chronic articular rheumatism in the upper extremities are in

[1] Ollier, *Revue mensuelle de médecine et de chirurgie*, vol. i., février et mars 1877.

every respect similar to those of the lower, and demand the same treatment.

As regards *the head*, both the bony skull as well as the soft and bony parts of the face are subject to deformities. In the cranial bones it is almost exclusively **premature ossification of the sutures**, or of the **epiphysial cartilaginous wedge of the base**, which causes deformity. Virchow[1] explains the abnormal formation of the skull of the cretin as caused by a premature synostosis of the separately situated osseous centres of the body of the sphenoid. At the time of birth the sphenoid consists of two pieces of bone, which are separated by a transversely placed cartilaginous disc, the intersphenoidal synchondrosis. After birth this synchondrosis begins to ossify from the lower surface upwards. As a rule, however, as Henle points out, the disappearance of the cartilage by the encroaching ossification on both sides proceeds very slowly, so that even so late as the age of thirteen there are still some remains of it to be found.

Next to this synchondrosis, the most important place for the growth of the base of the skull is the spheno-occipital synchondrosis, which first ossifies towards the end of the bone growth. Premature ossification of this synchondrosis stops the further growth of the base of the skull, and thus indirectly restricts the development of the brain.

Ossification of the bones of the calvarium generally proceeds from the margins. So long as these bones are still separated from one another by fontanelles and fibrous membranes growth proceeds rapidly; on the other hand, if the edges of the bone directly touch one another, growth is retarded, and if the bone edges overlap each other in the form of dentated sutures, growth only proceeds at a very slow pace. But beside this growth from the margins another kind also appears to exist, by which the cranium widens, viz. the absorption on the inner and the apposition on the outer surfaces. Henle points out that in several birds and in the ornithorynchus, the sutures and synchondroses of the skull are closed by complete ossification at a very early age, and that therefore a very considerable widening results from these *apposition* and *absorption* processes. In all cases with the higher mammals, including man,

[1] Virchow, *Entwicklung des Schädelgrundes*. Berlin, 1857.

growth from the edges of the bones plays by far the principal part, and when two bones coalesce prematurely with one another, further growth at this place ceases.

Now, in the case of each suture formed by apposition at the edges, growth occurs in a direction at right angles to the course of the suture, and premature ossification effects a retardation of growth in that direction. Thus premature ossification of the coronary suture stops longitudinal growth, and premature ossification of the sagittal suture stops the growth in width of the cranium. If a suture ossifies prematurely, it often happens, as Virchow pointed out, that a compensatory increased growth of the bone goes on in the other sutures, so that the internal cavity of the skull is not necessarily diminished, although its form undergoes great alterations. If the suture lies (as does the sagittal suture) in the middle line, or if it reaches equally far on either side (the coronary and lambdoid sutures) then, if premature ossification occurs throughout, the symmetry of the cranium is not disturbed. On the other hand, if the suture lies only on one side, as does the squamo-parietal, then premature ossification disturbs the symmetry of the calvarium by inducing a one-sided saddle-shaped depression (*Clinocephalus* of Virchow), which is compensated by increased projection of the forehead and of the posterior part of the vertex.

Treatment is, of course, useless for these deformities. We can but watch their slow progress and leave them alone, and hope that the brain, by reason of its great facility of adapting itself to altered conditions of space, may not be unfavourably influenced.

Deformities of the face may be occasioned by several causes. Thus we often find in severe cases of **torticollis**, from shortening of the sterno-mastoid, the lower side of the face remains smaller than the upper. So long as the head is awry, this inequality is not usually very noticeable, as the oblique position makes it very difficult to compare the two halves of the face. So soon, however, as the straight position is restored by means of tenotomy of the sterno-cleido-mastoid, the difference in the two halves of the face becomes much more perceptible. This difference, however, vanishes in the course of further growth, supposing that the operation is not performed too late,

that is, not later than between the fourth and eighth years of life. If it is performed later, the asymmetry will have attained to a greater degree, and the years of most active growth having passed, any compensation that may be possible will be very slow.

How this difference in development actually arises has not been absolutely determined. It appears as if the lower side of the face takes less part in the mimic, and perhaps also in the masticatory, muscular movements than the upper, whereby the retardation is induced both of the soft and bony portions of this side of the face.

A similar effect upon the growth of one side of the face is produced by *paralysis of the facial nerve.* If this occurs before completion of bone-growth, the affected side of the face, besides the great disfigurement which exists in consequence of the soft parts of the face being drawn over to the side which is not paralysed, remains much smaller than the other.

This fact has been experimentally confirmed by P. Schauta[1] who has proved that when the facial nerve is removed in growing animals, as near as possible to the stylomastoid foramen, the facial part of the skull on the paralysed side remains distinctly smaller than the other from retarded growth, and great asymmetry results.

In these cases it is undoubtedly the interrupted muscular movement which must be regarded as the cause of the retarded bone-growth, and such cases prove that the form and growth of the bones a·e greatly influenced by muscular action.

The mechanism of the masticatory apparatus is much deranged by **disease of one or both of the maxillary joints.** Inflammation of these joints, as it sometimes occurs in the course of acute articular rheumatism, renders mastication extremely painful. If the inflammation passes into the chronic stage, or begins as a chronic affection, it is much to be feared that the mobility of the joint will be lessened, or even entirely lost. We must contend against the commencement of this result with all the means in our power, for firm and permanent closure of the teeth (the so-called lock-jaw) is a condition which is not only very alarming in itself, but by its interfering with

[1] F. Schauta, 'Zerstörung des N. facialis und deren Folgen,' *Sitzungsber. d. Wiener Acad. Math.-naturw. Cl.*, vol. lxv. pp. 105-116, 1872.

eating severely threatens the general condition of the body by inducing starvation.

The treatment which must be adopted in these cases, in addition to the general anti-rheumatic remedies (especially when we suspect that the disease is part of a chronic joint rheumatism), consists in systematic passive, as well as, where possible, active movements of the jaw. By forcing apart the teeth by a screw machine we endeavour to obtain mobility in the maxillary joints, and to counteract the contracting influences, which in these cases generally depend upon cicatricial contraction. Certainly we have to fight a hard battle in treating these cases, for when there exists much inclination to contraction and ankylosis, we seldom succeed in preventing them. We may delay these results, but we cannot stop them altogether. By forcing the jaws apart, the teeth become eventually so loose and painful that we are forced to abstain from further attempts.

As a last means of preserving the mobility of the lower jaw, there only remains operative treatment, such as sawing through the jaw in front of the insertion of the masseter muscle, or resection of the condyloid process.

The *nose* often becomes severely disfigured, either by being displaced wholly in an oblique position or by its septum being bent sideways. The oblique position of the whole nose is either an original deformity, from deficient power of growth of one side, the result of which, though it may show but slightly at birth, may increase in the course of growth; or it is caused by pressure in the uterus, or at birth, especially when the latter is tedious and has to be hastened by the application of forceps; or, finally, it may arise from causes which affect the nose in later life, such as severe contusions, or fractures which are healed in a faulty position. Treatment may consist in repeated pressure with the fingers, which the patient may himself apply—an experiment which was tried first in the last century by Quelmalz,[1] though it is seldom that the individual possesses sufficient patience to carry out such treatment sufficiently long, *i.e.* for many years.

The following plan is more effective. A band made of steel

[1] Th. Quelmalz, *De narium earumque septi incurvatione.* Leipzig, 1750.

and padded with leather is made to surround the head at the level of the forehead. From this band downwards, on each side of the middle line, proceed two small steel springs with leather plates at their extremities, which are so applied against the projecting points of the nasal curve, that by pressure and counter-pressure they force the nose towards a normal position. If this apparatus is applied in childhood between the sixth and twelfth years of age, correction may fairly be expected, *i.e.* even if the exact median position of the nose be not attained, a marked diminution of the curve will be effected. In all cases a very long time is necessary to attain much result by this means.

An **oblique position of the septum** is still more difficult to rectify. It is sometimes seen bent so much to one side that it presses against the turbinated bones, and thus interrupts the passage of fluids, and even of air, upon the side affected. It may even happen that the septum by a double curve may cause narrowing or even closure of both nostrils. The inconveniences thus caused are very serious. In the portion of the nostril lying behind the obstruction an empty space is formed in which the mucus stagnates, and therefore becomes easily decomposed and offensive, causing great annoyance both to the patient and to those around him. Syringing with lukewarm water through the nostrils or the posterior nares certainly disperses the collected mucus, but cannot prevent its re-collection. Besides which, the speech is very nasal in consequence of the hindrance to the passage of air through the nose, and the nose presents a short, broad form which is not ornamental to the face. Breathing also is much hindered by closure of one, and still more of both nostrils. The patients are obliged to sleep with their mouths open, and often suffer from severe asthmatic attacks. There is thus very urgent necessity for remedying this painful affection, and there are two methods of doing so, viz. excision and forcible reduction.

If we adopt the plan proposed by Roser,[1] viz. to cut direct with the knife from the outside of the nostril, we can only reach the affected part when it is not situated very deeply. In a more backward position access is too much impeded to allow of any operation by means of the knife and forceps.

[1] Roser, *Handbuch der anatomischen Chirurgie.* Tübingen, 1875.

For this reason Blandin[1] and Rupprecht[2] constructed an excising forceps, which can be disjointed at the point of union, and which has at the end of one piece a cutting ring, and at the end of the other a corresponding plate covered with a thin layer of wood or leather. The forceps is used thus: The patient being under chloroform, the branch with the cutting ring is introduced into the contracted nostril, so that the ring is placed against the part of the septum which is most curved; the other branch is then introduced into the other nasal cavity. The two parts of the forceps are now connected and forcibly pressed together. By this means the ring cuts a piece corresponding to its own size out of the most obstructed place, and when the right sized instrument is chosen and the right place selected, this excision will allow the admission of air to both the front and back portions of the affected nostril.

This method, although not ineffective, is difficult because we cannot see what we are doing.

This difficulty may be avoided if we divide the soft part of the nose by Ollier's plan, from the top of the nose down to near the base of each ala nasi, the nose only remaining attached to the face by the angle of each ala and the soft part of the septum narium. Upon the hinge formed by these three points the nose is to be turned downwards, and free access to the cartilaginous and even to the bony septum narium is gained from above, so that the requisite excision with a knife or scissors can be made under the guidance of the eye; or if necessary we may even use forceps or chisel. It cannot be doubted that we are enabled by this method to correct all oblique positions of the septum narium, so as to perfectly remove the deformity; and, moreover, the separated portion of nose, if the sutures are not too few, runs no danger of sloughing, and its healing by first intention may safely be expected; nevertheless, we rarely find a patient who for this apparently small evil will be willing to undergo so serious an operation.

In order to avoid operation by the knife, A. Jurasz[3] has modified a procedure already published by Adams. He has

[1] Blandin, *Compendium de Chirurgie*, vol. iii. p. 33.
[2] Rupprecht, *Wiener med. Wochenschr.*, 1868, p. 1157.
[3] A. Jurasz, *Berl. klin. Wochenschr.*, 1882, No. 4.

had a special pair of forceps made, which can be taken apart, and the branches of which have at their points two steel plates, which are easily separated from the forceps and can be pressed together by means of a screw passing through their base. We first introduce half the forceps into each nostril, apply them to the obscured septum narium, and then close the instrument. Then we press the two branches so firmly together that the curve is rectified, and the septum placed in a median position. When this result is attained, both plates must be screwed to one another, and allowed to remain as compresses in the nostrils, whilst the forceps are withdrawn. After three days the screws are unfastened, and the plates taken away. Then, we first allow the swelling of the mucous membrane of the nose, which has been much irritated, or even ulcerated by the pressure, to subside ; after which two small ivory plates should be applied, one to each side of the septum narium ; these are tied together with a silk thread across the septum, and serve as splints to prevent a return of the curved position of the septum.

I have once tried this experiment, with, however, but partial success. The difficulty is as follows: The bony, and also to a great extent the cartilaginous, septum narium is fixed between two unyielding points of bone, the base of the cranium or its continuation, the nasal bones, and the hard palate. It becomes curved from growing too quickly, so that its fixed position between these two bone-points causes it to bulge laterally. Slight influences determine the direction of the curve to the right or to the left. Now, if the septum narium which is thus fixed be seized between the two lips of a pair of forceps and bent straight by means of considerable force, it can only accommodate itself to this force by breaking and becoming reduced by the overlapping of the broken edges. Whether this also happens when Jurasz's method is tried, especially in the case of the elastic and tough cartilage, I doubt very much. I believe rather that the septum narium, even when it has been in the clamp for three days, will not have lost the inclination to return to the lateral curve.

Deformities of the thorax are divided into those which are the consequence of deformities of the vertebral column, and those which occur without its participation.

The latter consist of pigeon-breast and of the deeply indrawn præcordium. In pigeon-breast the costal cartilages on both sides are bent with a concavity directed outwards, so that the front of the chest projects in the form of a wedge, which circumstance gives rise to its name, and also to its German name of 'Hühnerbrust' (fowl's breast), the protruding sternum being compared to the high crest which comes far forward in the middle line on the breast-bone of birds, and serves for the insertion of the powerful pectoral muscles. In the case of the indrawn præcordium, on the other hand, the lower portion of the sternum approaches abnormally the anterior surface of the vertebral column, whereby a deep and remarkable depression is seen, for as the sternum is only covered by the skin, the bony abnormality appears clearly outlined.

Though these two deformities are quite different in appearance from one another, they nevertheless owe their origin to the same cause, viz. rickets. The result depends upon which part of the thoracic wall has chiefly lost its power of resistance by the rickety softening, so that it may be drawn inward by the negative pressure produced by inspiration.

If the softening principally affects the costal cartilages, especially at their places of attachment to the ribs, then the latter yield to the inwardly directed force, and pigeon-breast is the consequence. On the other hand, if it is the lower portion of the breast-bone which is more yielding than the sternal insertion of the costal cartilages, then this part gives way to the pressure. After cessation of the rachitic process, and when the normal hardness of the bone-tissue is restored, these deformities may remain permanent.

In the course of years and with increasing growth, however, a spontaneous process of correction often takes place. The natural roundness of the lateral parts of the thorax increases, and thus the sternum returns to its normal position. This is the explanation why pigeon-breast is very seldom met with at the age of puberty, while in earlier years, corresponding to the frequency with which rickets occurs at this age, it is by no means rare.

The deformity of præcordial retraction is only very slightly subject to this spontaneous correction. This affection is much

rarer in childhood than it is in adults, but may, however, be regarded as an abnormality of but slight importance, as it but seldom causes inconvenience.

Treatment is but seldom necessary in these cases. It is quite useless to try to hinder or to cure pigeon-breast by circular bandages applied round the thorax. The only result of this attempt would be to cause a difficulty in respiration, which might seriously endanger the life of rickety children, who frequently suffer from severe pulmonary catarrhs. In later years likewise, when the rachitic process has ceased, we cannot hope to do any good with circular bandages. It would be more reasonable to employ for this purpose an elastic pressure, which would press the sternum towards the vertebral column, without affecting the lateral thoracic walls. though this proceeding is much impeded by the complication of the necessary apparatus. But the spontaneous correction which almost always takes place in the course of years makes treatment which is beset with difficulties unnecessary, and therefore the process is best left to itself.

If at the age of from eight to ten there remains some deformity, and its perfect disappearance is desired from considerations of personal beauty, then a long-continued gymnastic treatment is to be recommended—very carefully arranged exercises with the body hanging by the hands, so as by extension of both large pectoral muscles to produce outward traction upon the indrawn costal cartilages. It cannot be doubted that by this means the correction will be hastened. The retracted præcordium is inaccessible to effective treatment, for we have no means of restoring it to its original level. However, this defect in our power of treatment does not much matter, as the deformity is of but slight importance.[1]

Deformities of the vertebral column are extremely various, and of very great importance. The vertebral column forms the principal support of the trunk. In all the animal classes

[1] Both in cases of pigeon-breast and in depression of the sternum, I have found that children may generally be cured, and always greatly benefited, by the application of a gutta-percha or leather back splint in the case of infants, and of a light metal upright spinal support in the case of older children, for a few months or longer. The shoulders are thereby drawn backwards, and the thorax develops more freely and fully.—N. S.

in which it is found, it marks out the distinguishing morphological character, and thus Lamarck with good reason designated these classes of animals as vertebrates. To the vertebral column are attached all other parts of the body; in its cavity is enclosed the central nervous system, the upper part of which in the course of development becomes gradually enlarged and forms the brain, while the bony portions which surround it widen and form the skull. It not only forms the support for the central nervous system, but also for the vitally important thoracic and abdominal organs, and thus Galen not unjustly compared it to the keel of a ship. Corresponding with its great physiological importance, anomalies in position of the vertebral column have a disturbing influence upon a great number of the more important organs of the body, and corresponding to the many structures which are supported by this column; it is peculiarly exposed to various anomalies of position. In this last respect we may also notice the peculiar formation of this bony column, consisting as it does of seven cervical, twelve dorsal, five lumbar vertebræ, and five sacral vertebræ (coalesced into one bone), as well as the four coccygeal vertebræ, the coccyx (an unimportant rudimentary appendix). The erection of these small bones upon a proportionately narrow basis, their connection by the elastic intervertebral discs, their limitation by the oblique processes and laterally projecting transverse processes, which in the thoracic vertebræ articulate with the ribs, the ligamentous union of all these parts, which over the bodies consist only of the weak anterior and posterior longitudinal ligaments, but attains the highest degree of firmness at the processes, the attachment of numerous muscles, which are amongst the strongest in the whole body, the continued weight sustained by it owing to the erect attitude of man—all these peculiarities produce mechanical conditions of such complexity as to make our comprehension of the normal carriage of the body, and especially of the pathological deviations therefrom, extremely difficult.

It is not therefore surprising that deformities of the vertebræ have attracted more attention than have deformities of other parts of the body, and that their comprehension is as yet (on many points) imperfect.

The mechanical conditions of the normal vertebral column are to be found comprehensively detailed in 'Mechanik der menschlichen Gehwerkzeuge,' Göttingen, 1836 (Mechanism of the Human Apparatus of Locomotion), by the Brothers Weber; 'Handbuch der Anatomie der Gelenke,' Leipzig, 1863 (Handbook of the Anatomy of the Joints), by Henke; and 'Die Statik und Mechanik des menschlichen Knochengerüstes, Leipzig, 1873 (Statics and Mechanism of the Human Frame), by H. Meyer.

Here it may suffice to point out that the fœtus in utero is bent together in a forward direction, so that the vertebral column describes a bow convex backwards. This position, however, is not under normal conditions a fixed one; the newborn child, laid upon a horizontal couch with its legs extended, exhibits a vertebral column free from any curve. Such condition remains until the child is placed in an upright position, when the column under the influence of weight displays a uniform convex curve posteriorly. In the first attempts at walking, the pelvis assumes from muscular action a much tilted position, in which the middle point of the upper articular surface of the sacrum is vertically over the line joining the middle points of the two femoral heads. The upper articular surface of the sacrum thus acquires a position inclined 50° towards the horizontal plane, and in order to maintain its balance upon this oblique base, the vertebral column is obliged to assume a curve in the lumbar region with the convexity forwards. This curve is owing to muscular action, and almost exclusively to the action of the psoas and iliacus muscles. Further up, in the dorsal region, it bends convexly backwards, principally from the influence of weight, and as by the continuance of this bending up to the cervical region of the vertebral column the head would be tilted backwards, so here again by muscular action a bending of the vertebral column with anterior convexity takes place, the latter curve being maintained by the strong cervical muscles. Weight and muscular action are thus the actual factors in the formation of the normal curves of the vertebral column, just in the same manner as by the increase or loss of normal resistance pathological curvatures are produced. In the first years of a child's life the curves of the vertebral column are so little fixed that they disappear directly the child

is placed in the horizontal position. It is only in the course of further growth that the vertebræ and intervertebral discs assume forms so definite that the curves become permanent and no longer disappear in a horizontal position, and (according to the investigations of the brothers Weber) the curve in the dorsal region is produced chiefly by the shape assumed by the vertebral bodies, while in the lumbar and cervical the curves depend upon the shape of the intervertebral cartilages. Moreover, the arches influence very greatly the upright preservation of the curves by their intimate connection by ligaments and muscles, for if we divide the arches from the bodies of the vertebræ as L. Hirschfeld and, more recently, H. Meyer have done, the row of bodies loses its special curvature and becomes a swaying column, equally movable in any direction. Weight increases the curves and thus shortens the body. If the weight is removed the body rises again by the elasticity of the intervertebral discs and by muscular action, and the curves then become smaller. The Abbé Fontenu,[1] who very carefully investigated these conditions, found that the body in the morning, after repose in bed, is always taller than in the evening, when the burdening of the vertebral column during the entire day has pressed it together and the muscles are too fatigued to rightly sustain the vertebral bodies. The frequent exercise of his dorsal muscles which Fontenu underwent, while he endeavoured to hold himself as erect as possible at the measuring apparatus, finally led to a slight increase in height, which remained permanent, and is to be referred to the fact that the muscles of the back energetically used, even without assistance of the will, kept the vertebral column more erect than before. The more strongly the three normal median curves of the vertebral column are formed, the more secure is the column against the occurrence of lateral curvature; whilst a vertebral column with but slight anterior and posterior curves, running almost perpendicularly, has a great tendency to bend laterally.

Pathological variations in position of the human vertebral column are best divided into curves and angles. For the first, Kormann has introduced the very suitable name, the '*strophoses*' (from στρέφω = bend, turn); for angular deformity it

[1] Fontenu, *Mémoires de l'Académie des Sciences*, 1725.

is best to keep to the old Hippocratic name of '*kyphosis*' (from ὕβος = *gibbus*, a hump), though this was originally employed in two senses. Hippocrates was not able to draw a very great distinction between a curvature and angular deformity, so he called every posterior protuberance of the vertebral column 'kyphosis.' In later times, however, the expression 'kyphosis,' by reason of its association with the name of Pott, as Pott's kyphosis, has been exclusively applied to cases of angular deformity, so that it can no longer be separated from such cases, and had therefore best be reserved for them alone. According to this distinction, strophoses are sharply divided from kyphoses, curvature from angular deformity.

Flexions may occur in three principal directions; that is, namely, the convexity directed anteriorly, posteriorly, or laterally. For curvatures with anterior convexity the Hippocratic name of 'lordosis' remains distinctive, and excludes all possibility of mistake, in the same manner as does the name of 'skoliosis' for lateral curvatures.

For curvatures with posterior convexity, (which hitherto have been known by the name 'kyphosis,') a distinguishing Greek appellation corresponding to those given above is wanting. However desirable it may be to have such a better name for these flexions, yet I do not care to risk the experiment of suggesting a new one for them. We will commence with the curvatures of the vertebral column, which have a convexity directed backwards, and which I will therefore call 'posterior curvatures.' Of the three regions of the vertebral column, posterior abnormal curvature most generally affects the dorsal region, which has a backward convexity in its natural condition; but with a very extensive curvature, the whole vertebral column may be involved. As the normal backward curve of the vertebral column in the dorsal region is most generally—nay, is almost always—caused by the influence of weight, without much participation of muscular action, so also does pathological posterior curvature occur from the same cause.

Contraction of isolated groups of muscles, especially of the abdomen, would naturally bend the vertebral column conversely backwards, as we see temporarily when anyone bends his body from pain; but contraction of the abdominal muscles suffi-

ciently persistent to produce a permanent curvature of the whole column has, so far as I know, never been observed. The same is true of the muscles on the front of the neck as regards the cervical portion of the vertebral column.

Cicatrices, however, especially those from burns, may exert a persistent traction. Cases are known in which the cicatricial contraction, after burns of the integuments on the front of the neck, has been sufficiently powerful to draw the chin down to the sternum. It cannot be doubted that such a position, if maintained for many years, will act upon the form of the cervical vertebræ so as to produce fixed curvature of this part, with the convexity directed backwards. In the same manner, cicatrices of the front abdominal wall may cause a posterior curve of the lumbar vertebræ, by keeping the whole of the upper part of the body much bent forward; yet burns seldom occur in this part, and scars from other causes are rarely so extensive as to have any curving effect upon the vertebral column. Paralysis of the abdominal or dorsal muscles never leads to posterior but always to anterior curvature, such as may be seen in lordosis. In paralysis of the muscles of the neck, the head always sinks upon the chest owing to weight, and thus produces a backward curve of the cervical vertebræ; but a simple firm cravat, the lower edge of which rests upon the upper wall of the chest, is sufficient to keep the head in its normal position. In the course of chronic rheumatism the vertebral column sometimes bends into a large bow, convex backwards. This result is produced partly by diminution of the firmness of the bones, which lessens their power of resistance to the pressure of the upper portions of the body, and partly by contraction of the fibrinous exudations formed on the anterior surface of the vertebral column and of the inflammatory softened tissue. In consequence of bony coalescence of its individual parts, such a vertebral column may then be changed into one solid bony mass.

The forms in which backward arching most often come under observation are as follows:—

1. *Rachitic posterior curvature.* If a rachitic child of from 2 to 3 years old—that is, at the age at which the normal curves are tolerably well indicated—is made to sit upon a flat

surface, we shall find that the back presents one single uniform curve, with its convexity directed backwards. If we place the child in the horizontal position the curve disappears and the vertebral column becomes horizontal also. Thus it is shown that the curve is not fixed, and it very seldom becomes so. The results are explained by the great laxity of the ligaments and muscles, as well as by the softness of the bones, conditions which are very characteristic of rickets. The resisting power being diminished, weight curves the spinal column backwards. If after the disappearance of rickets the muscles regain their power, and the bones and ligaments their firmness, then the back curve disappears likewise, and the back attains its upright carriage with the normal curves. I have never seen rachitic back curves become permanent, except indeed when lateral curvature was also present, in which case very serious deformities always arise.

The only treatment which is necessary is to place the child for a long time in a horizontal position upon a firm couch, and by general treatment to cure the rachitic process as soon as possible. If the children are very actively inclined as the disease begins to subside, it will be necessary to support the back by means of a whalebone corset.[1]

2. *Posterior curvature in youth* is known by the name of '*round back*.' Girls are much more liable to this affection than boys. Here, also, it is the laxity of the ligaments and muscles which permits abnormal curving of the back from weight, especially when bone-growth has been very rapid. Now if it also happens that the girl or boy has to remain for many hours of the day sitting in a bent-forward position while writing, sewing, &c., the curve of the back is greatly increased. Nearsighted people are often affected with round back, and carry their heads poked forward. The whole process is rather an anomaly of carriage than a disorder, nevertheless it is extremely desirable to counteract the condition in good time; as, otherwise, it is to be feared that in the course of years, and especially in old age, it may become a serious inconvenience.

[1] An excellent plan of treating these cases is by means of a back splint of gutta-percha or leather, attached by means of an abdominal bandage and by armlets. The thorax is thus not compressed.—N. S.

The treatment of these cases consists in strengthening the body generally, and especially the dorsal muscles. Good nourishment, frequent exercise in the open air, cold rubbings, baths, swimming, friction of the back with spirit liniments, and lying upon a perfectly horizontal firm mattress, are the fundamental points of the treatment.[1]

Strengthening the muscles by means of suitable gymnastics is also of great value, but this point is discussed later on with reference to skoliosis. For support and upright carriage of the back, it may become necessary to wear a corset, or so-called straightener. A description of the corset will be found in the details of treatment of the first stage of skoliosis. As regards the straightener, it frequently fails, owing to the girdle, by which the back is to be corrected, being applied to the waist, *i.e.* in the space between the last ribs and the crest of the ilium. This position is a very insecure one, as it has no bony stay, but is supported only by the soft parts of the body, and then the distance of the girdle from the place which requires correction is too small to admit of any real effect. I reject, therefore, all straighteners which are thus constructed, and among them the well-known straightener of Bouvier. The only thing which these apparatus effect is to draw back the shoulder-blades, and that is not even desirable, whilst the vertebral column preserves its backward curves unaltered. A properly constructed appliance must, like the corset, be supported on the pelvis, as this is the only part which has firmness enough in itself for correction of the back. A well-padded girdle surrounds the pelvis at the part between its anterior superior spine and the summit of the great trochanter, and is fastened by a buckle in front, just over the symphysis pubis. Padded elastic strips of steel rise from the girdle on each side of the vertebral column to the upper level of the shoulder-blades. From this point they surround the shoulders from below, and finish either by plates on the anterior surface of the shoulders or else pass into leather straps, which

[1] I have used a prone couch for patients, after the pattern used by Verrall, the inventor, with remarkably good effect. Every movement of the body, when the patient is upon this couch, brings the dorsal muscles into action, and even in the quiescent state the back tends to assume a normal position, whereas reclining in the supine position relieves the dorsal muscles from all use, and movement tends to round the back.—N. S.

again are fastened to buckles which are on the end of the back uprights. The bending of the upright is so arranged that it accommodates itself to the normal curve of the lumbar vertebræ and then inclines backwards. The apparatus thus leaves the chest and abdomen free, and only confines the pelvis and shoulders. This apparatus is generally called after Heather Bigg, who, even if not the first inventor, was the principal advocate of this useful and elegant apparatus, of which he was the maker. Apart from the corset proper this is the only apparatus, at least to my knowledge, to which one can properly apply the name of a straightener, for in fact it does uphold the vertebral column, and does not confine itself to drawing back the shoulder-blades.[1]

Finally, *extension* must be mentioned. This may either be applied in the horizontal, the inclined, or the vertical position. In the latter case the head is either drawn up by means of a collar, applied to the chin and back of the head, by a weight and pulley, or by means of the same collar the head is fastened in a certain degree of tension to a steel spring rod which extends down the back, and is supported by a pelvic girdle, as in the original Minerva machine of Le Vacher. Further particulars of this machine are given under the head of Treatment of Skoliosis.

The object of this treatment is to restore the curved vertebral column to the straight position by extension and counter-extension at opposite ends, and this idea at first sight appears very plausible. But our opinion will be very different when we consider the subject more carefully.

Posterior arching of the vertebral column is never caused by traction in the front of the body, which one might try to remove, but is owing to the fact that, by decrease of resisting capacity, the vertebral column becomes bent by weight. Now, if we use extension of any kind whatever, the back certainly is

[1] Beneficial as this apparatus is in some cases, it yet has the disadvantage of interfering with the muscles of the back, so that the longer the apparatus is worn the weaker the muscles become from want of action. When it is desirable to encourage the development of the muscles, this may be done by an apparatus which prevents bulging of the back posteriorly, and also allows room for the muscles to be used. See *The Surgery of Deformities*, p. 190, by Noble Smith.—N. S.

stretched quite straight as long as the extension is kept up, but as soon as it ceases the back subsides all the more, since its muscles and ligaments are subjected to powerful stretching, on the cessation of which they are less capable than before of preserving an upright carriage in opposition to weight. The result is consequently a very temporary one, and the after effects rather hurtful than beneficial. For this reason, which is not theoretical, but is supported by practical experience, I am opposed to all extension for backward curvature in the young.

The completely opposite plan recommended by Wilson, of Edinburgh, is the carrying of weights on the head. Wilson devised this apparently paradoxical plan of treatment as a result of his observation that the milkmaids in Edinburgh, who carried cans of milk upon their heads, exhibited almost without exception a remarkably erect and graceful carriage. He believed that he could utilise this observation for the treatment of round back. The observation is quite correct. In order to balance properly any heavy object upon the head the vertebral column must be well extended by muscular action, and kept in the median line by delicate muscular adjustment. Anyone whose spinal column would be compressed by the weight would hardly be able to exercise the muscular play necessary for balance. If such a carriage is maintained for a series of years it becomes fixed, so that it can be kept up, even in later years, without special exertion, just as soldiers are remarkable in old age for their erect carriage, which they have acquired by drilling during early years.

Nevertheless the observation is of no avail for the treatment of round back. Wilson overlooked the fact that he was observing sound and strong country people, whereas we have to deal with weakly town children. If these latter had weights placed upon their heads, the result would be rather an increase than a correction of the deformity, for both muscles and bones are too weak to present a strongly extended vertebral column in opposition to the downward pressure. In these circumstances the vertebral column, under the increased effect of weight, subsides still more, and the plan is thus quite unfitted to straighten round backs.

3. The third form of posterior curvature is *the back bent by*

labour. Every occupation which entails long-continued stooping, especially when heavy weights are carried, leads in the course of time to permanent curvature. Bones and ligaments change under the effect of weight, and the muscles also lose the power requisite to contend against it. The working capacity suffers but slightly, and naturally there is no question of treatment.

4. The last kind is *the bent back of old age*. In great age the muscles become weak, the bones soften in the form of the well-known 'senile osteomalacia,' the fibrous tissues yield, and, as a consequence of these conditions, the vertebral column sinks under the influence of weight, and the greatest curve is found between the shoulders. It is well known that old women are especially apt to become bent when they lay aside their corsets permanently. In most cases, we shall hardly feel induced to treat this deformity. Should, however, it be necessary to do so, we should find the best supporting apparatus in a whalebone or steel corset. Sometimes senile bowing of the spine becomes very serious. The following case may serve as an example :—

Wilhelm Grimm, aged 60, entered the army at the age of 17, and served 18 years in the cavalry, first as trumpeter and later as band-master. Then for several years he acted in various civil capacities, and finally for nine years as conductor of a small theatrical orchestra. He was obliged to give up this situation when 54 years old, as his spine began to bend backwards, accompanied with severe pain. In the six years following the curve had gradually increased ; the pains, however, had latterly ceased. Disturbances of digestion had not as yet commenced, nor had pareses of the legs occurred, but occasionally a convulsive movement was perceptible, especially in the left leg. On examination he was found to be a strongly built man, but much bent. On the front surface of the body the skin of the abdomen lay in a number of horizontal folds, and the lowest ribs lay deep in the fossa iliaca. On inspection of the back there was found in the lower part of the spine a considerable curve with its convexity backwards, without any lateral deviation. This curve extended from the 10th dorsal to the 3rd lumbar vertebra. From the uniform character of the curve it was undoubtedly a strophosis.

Forward curve of the vertebral column (lordosis) is found almost exclusively in those portions of the column which normally exhibit a considerable degree of forward curving, viz.

the cervical and lumbar portions. A forward curve of the dorsal portion is mostly only temporary, and even then is rare. As the normal forward curving in the cervical and lumbar regions is almost exclusively due to muscular action, so the increase of the same to pathological lordosis is generally to be referred to the same cause, and it is only by muscular failure from paralysis or atrophy that weight will bend the dorsal part of the spine into lordosis. Lordosis is seldom congenital, and if so it occurs almost exclusively in monstrosities which are incapable of life, so that this form is of no interest here. Acquired lordosis of the cervical part is also very rare, and is caused by muscular or cicatricial contraction of the back part of the neck.

Duchenne observed such a case, in which the head, by reason of contracture of the right splenius capitis muscle, was permanently much bent backwards to the right, whereby the cervical part of the column was much bowed forward. Lordosis in the lumbar region is tolerably frequent, but it is mostly the consequence of an increased tilting of the pelvis, and but seldom depends upon changes primarily affecting the lumbar vertebræ or the adjacent parts.

Of these cases the first to be mentioned are those of people who, from habit or the nature of their vocation, bend the back very much forwards, the position in time becoming permanent. Towards the end of pregnancy every woman is compelled to walk with the lumbar region projecting forwards in order to balance the weight of the pregnant uterus by a backward carriage of the upper part of the body. As this condition does not last long, the lumbar lordosis disappears after parturition. Large ovarian tumours which have existed for many years might leave behind them a lumbar lordosis, even after their removal by operation, but I am not aware that observation so far has confirmed the supposition. Pedlers, who carry their wares before them, often acquire a permanent lordosis, which obliges them, even when they are not burdened, to walk with the lumbar spine much bent forwards. In the same manner may be explained the remarkably upright carriage which is often to be seen in tailors, and which has given rise to the popular witticism, 'The tailor walks as if he had swallowed

his yard.' Long-continued sitting upon the tailor's table, with the legs strongly drawn up, leads to shortening of the ilio-psoas muscles, whose points of attachment have been approximated, and then when the hip joint is extended, as is necessary in walking, these muscles draw the lumbar region towards the thigh, and thus cause a forward curve.

Paralysis and atrophy of the abdominal muscles often cause forward curving of the lumbar region, and, as Duchenne has shown, so also does paralysis of the long dorsal muscles. If the patient has lost the use of the muscles of his back he can no longer maintain the usual upright carriage of the body, for as the muscles of the front surface of the body have lost their muscular antagonism in the back he will be in danger of falling forwards at every movement. The patient soon discovers instinctively that he can stand upright very well if he carries the upper part of his body well back. In this position he balances himself between the action of the abdominal muscles and the weight of the body, and succeeds tolerably well; backward inclination naturally takes place in the most movable portion of the lumbar region, and this consequently acquires a marked anterior curve. On the other hand, if the abdominal muscles are paralysed, the patient, when adopting the ordinary upright carriage, runs the risk of falling backwards, as now the long muscles of the back have lost their antagonists on the front surface of the body. Here, too, he assists himself instinctively by curving forward the lumbar part of the column, which in these cases is still more marked. He draws the lumbar region strongly forward by the ilio-psoas muscles and bends the upper part of the body backwards. He now balances his body by the action of the ilio-psoas and erector spinæ muscles, whilst the weight of the



Fig. 2.

protruding abdomen counterbalances that of the receding upper part of the back. In this way the incapacity of large groups of muscles both on the front and back of the body gives rise to lordosis, though the carriage is not quite the same in both cases.

The accompanying illustration (fig. 2) is an example of a forward arching of the lumbar vertebral column in consequence of atrophy of the long dorsal muscles. The case is that of a boy 4 years old, who had been affected by atrophy for a year without any evident cause.

Paralytic lordosis never becomes fixed. Even when the patient has had this deformity for years, the forward curving disappears at once when we place him in the horizontal position, the vertebral column closely adapting itself to the couch.

We cannot, therefore, consider this kind of lordosis as a fixed deformity. Muscular contracture is a still less frequent cause of lordosis than paralysis. The muscles which by their contraction would produce this position are the iliacus and psoas, yet this has never been observed as dependent upon nervous influence. On the other hand, it appears that the iliacus and psoas muscles may be cicatricially shortened when suppuration has taken place in them, either from primary inflammation or from vertebral abscesses passing downwards in their tissue.

If in the latter case the muscle contracts, the lumbar region becomes much bent forward when the body is in an upright posture. But this anomalous position very rarely becomes fixed as a deformity involving alteration of the form of the bones. As soon as the patient sits, and thus approximates the points of origin and insertion of his psoas muscles, the lumbar region becomes extended just as it does in the horizontal position with flexed thighs. It is in most cases useless to attempt treatment for lordosis, but if the case is one of cicatricial shrinking of the psoas muscle, we may try to remove it by extension.

In paralysis and atrophy electrical treatment is indicated, but with small prospect of improvement. Lordosis consisting of fixation of an habitual anomaly of position naturally requires no treatment, as it causes no inconvenience.[1].

Finally, the most frequent form of lordosis is that caused

[1] In many of the cases of lordosis described above, the discomfort and

by an increased forward inclination of the pelvis. When the natural tilting of the pelvis is increased, the upper articular surface of the sacrum is inclined at a greater angle to the horizontal than the normal one of 50°, and in order to preserve the upright carriage of the body upon this much inclined base the patient is obliged to bend his lumbar region forwards, and to lean the upper part of the body correspondingly backwards.

The degrees of pelvic inclination and of forward curving of the lumbar region thus precisely correspond, and this form of lordosis is very appropriately designated as *compensation lordosis.*

The causes which produce an increased inclination of the pelvis depend almost exclusively upon disease of one or both hip joints. If only one hip joint is diseased a certain degree of lateral curvature occurs with the lordosis, the convexity of the curve presenting towards the side of the diseased hip; on the other hand, if both hips are diseased to an equal degree, the lordosis curve of the lumbar region remains in the middle line.

Among the abnormal conditions of the hip joint the first to be mentioned is *congenital dislocation.* This is caused, as already stated, by a deficient formation of the head and neck of the femur, as well as of the acetabulum. In consequence of this deficiency the rudimentary head of the femur does not find a firm support in the normal part of the pelvis, but mounts upwards and backwards upon the outer surface of the ilium. As a consequence of the abnormal transverse axis thus created the patient is compelled, in order to preserve his balance, to increase the inclination of his pelvis by muscular action, and this inclination leads to an increased anterior curvature of the lumbar vertebræ. On account of the considerable upward displacement of the heads of the femora on the outer surface of the pelvis, the lower extremities of a patient affected with congenital double dislocation of the hip joint appear extremely short. The prominences of the trochanters, distinctly marked externally on the posterior outer surfaces of the pelvis (and these prominences almost reach to the iliac crests), together with the deep

inconvenience may be relieved by the use of an instrument in the form of an artificial spine, which supports the shoulders and abdomen and assists the patient in balancing the body.—N. S.

hollow in the lumbar region, and the consequent prominence of the abdomen and the waddling gait which is caused by the deficient firmness in the articular connection between the thigh and the pelvis, give to persons affected a very peculiar appearance, which to the practised eye is diagnostic without any further examination. If the deformity affects only one hip joint (and women appear to be much more frequently subject to this than men, and in the left hip joint more often than the right), then in the usual way of standing with the knees and feet together the affected side of the pelvis is depressed, and the lumbar vertebræ form a curve with the convexity turned forwards and towards the diseased side. If we raise the depressed side of the pelvis by placing a support under the foot of the shortened leg, the lateral curvature of the lumbar vertebral column disappears, and even the lordosis becomes somewhat less. In consequence of this fact, patients with one-sided congenital dislocation are often able to conceal their defect almost entirely by wearing a thick sole on the affected side, which restores the equilibrium, or by only touching the ground with the toes, which is easy for women to do, as their clothing hides this manœuvre.

If this habit is continued for many years the foot may in consequence become fixed in the equinus position by retraction of the gastrocnemius muscle, a result which is, under the circumstances, very desirable, as in this case the lengthening of the leg caused by the talipes equinus has the result of compensating the shortening caused by the high position of the trochanter.

Inflammation of the hip joint very often produces lordosis of the lumbar region, and in this case two different mechanical factors co-operate. The first is the upward movement of the trochanter to the outer surface of the ilium, in consequence of a so-called inflammatory or spontaneous dislocation, or as a result of the well-known widening of the socket backwards and upwards, a result which so very often occurs in the course of coxitis. This is a precisely similar mechanical factor to that which occurs in congenital dislocation. The point of motion of the joint moves outwards and upwards, and thus an increased pelvic inclination is produced, which again produces

forward curvature of the lumbar vertebræ. The second mechanical factor in coxitis, and one of early occurrence, is the shortening of the muscles descending along the front of the pelvis to the thigh, especially the iliacus, psoas, and pectineus. The hip joint is flexed in almost every case in which it is inflamed, and some degree of this flexion remains permanent, after cure of the disease, through contraction of the above-mentioned muscles. Now if the patient who is afflicted with such a flexed position of the hip joint wishes to assume an upright position of the body, he can only do so by approximating the points of origin and insertion of these muscles, by curving the lumbar vertebræ forwards and increasing the inclination of the pelvis. As coxitis but rarely affects both hip joints an inequality between the two sides of the body exists, inasmuch as one half of the pelvis is depressed in consequence of the shortening of the affected leg, which always exists in these cases. Therefore in addition to the lumbar lordosis, a certain amount of lateral curvature is superadded, with the convexity directed towards the side of the contraction. This latter, however, always disappears as soon as we have compensated the inequality by placing a support under the foot of the affected side. To compensatory lordosis the rule also applies that it never, or at least very seldom, becomes fixed. This is because, even after the abnormal position of the body has lasted a long time, no considerable alteration in the form of the lumbar vertebræ takes place, so that neither by bony coalescence nor by contraction of the muscles, fasciæ, or ligaments do the vertebræ become unalterably fixed to one another in the abnormal position. The proof lies in the fact that simple anomalies of carriage and position seldom become fixed even after lasting a long while, unless changes take place simultaneously from disease of the displaced parts, such as softening of the bones, inflammation or cicatricial contraction of the muscular and fibrous tissues—changes which, if they occur, are very likely to cause such fixation.

As lordosis in these cases is exclusively the consequence of deformities of the hip joint, the problem of treatment is to combat these deformities. If this succeeds, though it often fails owing to great difficulties, the lordosis disappears of itself.

Lateral curvature of the vertebral column (**skoliosis**) is much more frequent than either of the two curves just described, and the mechanical conditions in the former are much more complicated than in the latter.

The preservation of the upright position of the vertebral column depends upon the regular form of the vertebræ and intervertebral discs composing it, as well as upon the uniform action of the traction and pressure influences operating upon it on either side. So long as these conditions are equal upon each side, there is generally either no curve of the column, or the curve has its convexity directed either forwards or backwards without leaving the median line, as in the instances of curves already described. The factors producing lateral curvatures may depend upon congenital inequalities of the vertebral column itself, or on unequal operation of weight upon the two halves of the spinal column, or on unequal muscular action, or on cicatricial contraction.

If the inequality of these influences has reached a very high degree, it cannot be doubted that even a vertebral column in its osseous and ligamentous parts may be thus forced into the fixed deformity of skoliosis. Generally, however, the deviating forces have no such intensity, and as, even in these cases, lateral curvature is common, we are compelled to assume that the constituent portions of the column itself undergo alterations which make it susceptible to the lateral influences. We have already seen in lordosis how seldom such anomalies in position of the vertebral column become fixed if the osseous and ligamentous portions possess their normal resistance, and we thus arrive at the conclusion that also in skoliosis the same conditions are present; a conclusion, moreover, founded upon direct observation.

The normal movements of the vertebral column consist in antero-posterior and in lateral flexion, as well as in rotation upon the vertical axis of the body, by which the front of the body may be turned more or less to the right or to the left, while the pelvis remains stationary.

The cervical vertebræ have the greatest mobility; next to these the three lowest dorsal and two highest lumbar; then the three lowest lumbar vertebræ. The least movable part of the

spine consists of the upper nine dorsal vertebræ, which, in consequence of the overlapping of their spinous processes, and the lateral limitation by the oblique articular processes, and the articulation of the ribs to the vertebral bodies and to the summits of the transverse processes, are the most obstructed in their lateral movements. All normal movements of the vertebral column are naturally produced by voluntary muscular exertion.

Lateral curvature of the vertebral column is either simple or double. In every simple lateral curvature the upper end of the vertebral column is removed from its relative position to the basis of the sacrum,—the point of the odontoid process (the position of which can be determined by outward examination of the occipital spine) is displaced laterally, so that a plumb-line falling from the external occipital spine no longer impinges upon the middle of the base of the sacrum, but is removed laterally from it. The curve may continue to increase laterally so long as the perpendicular line, let fall from the centre of gravity of the whole body, remains within the four-sided figure formed by the apposition of the feet. If the lateral curve is carried beyond that line the body falls, unless it receives external support. The double curve of the vertebral column is produced voluntarily with difficulty, but it always takes place without either our knowledge or our intention when we raise a weight high by means of one arm, or when we are obliged to hold the body straight when the position of the pelvis is oblique. If we raise a weight with the right arm a curve is formed in the dorsal part of the column with its convexity directed towards the right, and a smaller opposite curve in the lumbar portion. The reverse ensues from exclusive loading of the left arm or shoulder. If we slightly bend the left leg at the knee joint, we stand almost exclusively upon the right leg with very slight assistance from the left. In this case the left half of the pelvis sinks considerably, and at the same time the rotation of the pelvis increases about the transverse axis, whereby the gluteal region of the right side becomes more prominent. The French painters call this position 'se hancher,' but there is no special German term that I know of.

In order to keep the body erect in this altered position of the base, the vertebral column must accommodate itself by assuming a special curve. The increased forward projection caused by the pelvic tilting is responded to by the lumbar vertebræ (lordosis); the lateral sinking of the pelvis, on the other hand, by the formation of a lateral curve, of which the convexity is turned to the depressed side of the pelvis. If we examine the spinous processes carefully upwards we find in the dorsal region a much smaller lateral curve with an opposite convexity. The mechanical reason why the vertebral column assumes a double curve, and not a simple one, for the preservation of the balance is not so easy to determine. The conditions are very complicated, the preservation of the balance upon the small supporting surface which the human feet afford being a peculiarly involved process, which is only maintained by means of constant innervation from a special motor centre in the brain of a very large number of muscles and of their reciprocating harmonious action.

In every double curve of the vertebral column the plumb-line let fall from the external occipital spine may either touch the middle of the sacral basis, or it may deviate laterally from this point. The first is the case when both curves have exactly the same intensity, and therefore perfectly compensate each other. We speak of the first as a case of vertical curvature, whilst we designate the other as an inclined curvature.

It is a question of the greatest importance whether every lateral curve of the vertebral column must be accompanied by rotation. By rotation we understand a position of the vertebræ, in which the axis of their bodies describes a larger curve than the line connecting the summits of the spinous processes. I agree entirely with those who think like H. Meyer and Henke, viz., that every lateral curve of the vertebral column is accompanied by some degree of rotation. If we examine the anterior and posterior portions of the vertebral column, we see at once that the disposition of the two parts is quite different, the one from the other. Anteriorly we have the row of bodies and intervertebral discs, the weak anterior and posterior longitudinal ligaments, and only at the cervical and the lumbar regions the insertion of a few muscles; posteriorly, on the other hand, the

row of arches with the spinous, transverse, and oblique processes, fastened together by extremely strong ligaments and surrounded by numerous muscles, which are amongst the strongest in the body. A column composed of such unequal parts cannot possibly perform a purely lateral movement. If it bends sideways it can only do so by adding to this side curve a slight degree of rotation, i.e. the row of the bodies must describe a somewhat larger curve than the row of the spinous processes. This explanation also applies to the double curve, only here the rotation is double also, as in each curve the bodies are turned to the convexity; the arches, on the other hand, to the concavity; and, with regard to these, the degree of rotation of the vertebræ which are involved in each lateral curve is very slight under normal conditions.

From the physiological movements of the vertebral column abnormalities may arise, which are designated by the term *habitual anomalies of position.*

Some occupations induce a certain curve or position of the vertebral column very frequently. Hereto belong the habitual carrying of objects upon one arm, e.g. the school satchel; the frequent repetition of a definite lateral posture when writing, drawing, violin playing, or in many other daily occupations; the habit of standing with one leg bent, therefore with the pelvis oblique, sitting on oblique benches or stools, &c. The vertebral column of an adult is hardly ever permanently influenced by these one-sidedly acting causes unless they are extremely severe.

Even in youth or childhood the vertebral column, if it is strongly developed in its bony and fibrous parts, bears these influences for a long time without suffering any permanent alteration. On the other hand, if the spine is weak it may easily happen that the unequal conditions of pressure which result from habitual anomalies of position may produce an unequal form of the two sides of the vertebral bodies, and thus give to the vertebral column a permanent lateral deviation. Habitual anomaly of position may thus become developed into skoliosis, and whilst the first disappears as soon as one places the body in a symmetrically upright, or in the horizontal position, in the latter the lateral deviation continues in both these

postures, as it depends upon certain changes of form in the component parts of the column.

It must nevertheless be pointed out, that not every fixed skoliosis is the result of an habitual bad position.

The bony deformity which causes skoliosis to become permanent may be produced by other causes than these; it may, as we say, be primary, so that the unequal carriage of the body is first produced by the development of lateral inequalities in the vertebræ. In some cases it may even be very difficult to determine whether the bad position is the cause or the consequence of the deformity of the spine, and even the most careful consideration of all the causes before us is often insufficient for a positive decision.

Those cases in which the variation of position is primary and remains so, or only secondarily leads to deformity of the bones, may be divided as follows:

1. Lateral curvature from *muscular pain.* The deformity may be the result of rheumatic myositis (lumbago), caused by the patient, in order to relax the painful muscle, bending the vertebral column towards the opposite side. If, as usual, the pain disappears after a few days, the spine becomes straight again. On the other hand, if from any reason shrinking of a painful, inflamed, or injured muscle occurs, as, for example, is very common after suppuration, the lateral curve of the column becomes fixed by contraction of the cicatrix, and may, if it lasts long, lead to alteration in the form of the bone, so that at a later date, even if we divide the cicatricial band, the straightening of the vertebral column is prevented. Quite similar is the formation of a lateral curve of the spine in consequence of shrinking of an inflamed pleura. The cicatricial contraction of the fibrous adhesions bends the vertebral column to the opposite side, and if this anomalous position exists for long, it will correspondingly alter the form of the spine and ribs, so that the skoliosis will now remain fixed even if it be possible to get rid of the primary cause, i.e. the contracting cicatricial tissues.

2. Lateral curvature from *repeated oblique position of the pelvis.* Everyone who walks about with uncompensated shortness of one leg is obliged to sink the affected side of the

pelvis, and correspondingly to bend outwards the lumbar vertebræ with the convexity directed towards the side on which the pelvis is lower. When the patient sits or lies down, the oblique position of the pelvis disappears at once, and consequently the lumbar part of the spine again returns to the median line. Thus in these cases the oblique position of the pelvis is never persistently maintained for a long time together, and consequently it is relatively seldom that in an individual whose bones are normally strong the bad position becomes a fixed bony deformity. But deformity is very likely to happen to delicate children, whose tissues possess but small powers of resistance, especially girls between the ages of ten and fourteen. In these cases, there is as a rule no shortening of one leg,[1] the sinking of the pelvis on one side being generally due only to bending the left leg at the knee from habit or weariness, when the body is supported almost exclusively upon the right leg, with the pelvis sunk towards the left.

3. Lateral curvature in consequence of *paralysis or contracture.* This form is the rarest, and depends upon anomalies of muscular enervation in consequence of infantile spinal paralysis, cerebro-spinal or tubercular meningitis, apoplexy, or cerebral tumour or softening, which by paralysis of groups of muscles on one side, or by their spastic contraction, seriously disturb the balance of the muscles on either side of the spinal column. Under these circumstances the column even of grown-up people may be affected by serious deformity.

Permanent skoliosis is distinguished from the habitual kind by its remaining the same under all circumstances—that is, in standing, sitting, and lying positions ; in sleep, narcosis, and death ; and that in the last case it is not removed even by dividing all muscles and ligaments, for it depends upon deformity of the vertebræ themselves. If the curve is not very great, it is popularly designated 'high shoulder' if it affects the dorsal portion of the vertebral column ; and 'high hip' if it affects the lumbar portion, because to the outward view these prominences are more apparent than the curving of the vertebral

[1] In sixty-eight cases of lateral curvature I found that twenty had one leg shorter than the other, in few of which cases was there any history of a cause of such inequality.—N. S.

column itself. If, on the other hand, the curve is very pronounced, then the mildest expression for it is that of 'humpback.'

Humpback caused by skoliosis is distinguished from that caused by Pott's kyphosis—i.e. spondylitis—in that it always presents a strong lateral deviation, whilst kyphotic humpback keeps with few exceptions strictly to the middle line. As to the relative frequency with which these two kinds of humpback occur, they appear, according to observations which I have made in the streets, to be tolerably equal. Precise medical observations as to the frequency of these conditions are scarce, as the patients who are afflicted with this great degree of curvature are mostly used to their affliction, and do not trouble themselves about medical help. The Greek and Roman physicians often confused these two deformities together, because, as Morgagni rightly remarks, they had not sufficient opportunity of examining the condition after death. Nevertheless we can adduce proof from the works of the poets, that a raised shoulder from skoliosis was an affliction well known to the ancients. Thus Ovid sings ('Ars amandi,' Cantus III.):

> Conveniunt tenues scapulis analectrides altis,

('Small shoulder-pads are becoming to high shoulders'), which can only apply to the skoliotic curve.

The first important question which requires explanation in respect to fixed skoliosis is this: Is the human vertebral column perfectly straight normally? If one answered this question from observation of the line of the spinous processes in the living, we should hardly venture to answer in the affirmative. But the case is different when we examine the front surface of the vertebral column, which naturally can only be seen in post-mortem examination. If we examine the row of vertebræ of a large number of cases at different ages, post mortem, the body being perfectly horizontal and all necessary organs removed, we find in a very large percentage of cases distinct deviations from the median position, and the most frequent variation is a curve in the dorsal region to the right, which reaches its greatest extent at the fifth and sixth dorsal vertebræ. Now for the frequency of this curve there are two explanations

in anatomy, or rather in physiology, viz. the position of the aorta on the left side of the vertebral column, and the predominant use of the right arm. The aorta, after it has crossed the left bronchus, reaches to the left side of the third dorsal vertebra, and then descends with a gradual curve, so that it first reaches the exact middle line on the anterior surface of the third lumbar vertebra. Sabatier was the first to point out, with reference to this question, that this position of the aorta weakened the left side of the vertebral column, inclining it to bend towards the opposite side. This question has been very enthusiastically discussed by eminent French anatomists. Cases have been observed in which, with transposition of the viscera, the spinal curve took the opposite course, but there are also cases in which no alteration took place, and others in which in a normal position of the aorta the curvature was towards the left.

The more frequent use of the right than the left arm was in old times generally explained in this way, that its muscles were stronger, and thus attained a superiority over those of the left arm. This assumption has long been recognised to be an erroneous one. If the question were one of greater strength in the muscles of the right side, we should expect on the contrary that the curve would direct its convexity to the left. Moreover the mechanism of all muscles between two bony points movable in opposition to each other is so conditioned, that by muscular contraction the more movable approaches the less movable bone. Now as the shoulder-blade is undoubtedly movable to a much greater degree than the vertebral column, we should much sooner expect, from the increased strength of the right shoulder muscles, an approach of the shoulder-blade to the spinal column, than a curvature of the latter.

The conditions, however, appear quite different when we consider that in conjunction with the predominating use of the right arm this arm is more commonly weighted than the other. Whilst the person endeavours in carrying a weight on the right side to preserve an upright position by displacing the centre of gravity, he bends the vertebral column towards the right in the dorsal region, by contraction of the left dorsal muscles, and from this position unequal conditions of pressure result, which

produce a greater weighting of the left side of the dorsal vertebræ than of the right.

Now if conditions are present which lower the capability of resistance of the vertebral column against this unequal weighting, such as may especially be the case when the bones are abnormally soft, or in a widening of the epiphysial zone of growth of the vertebral bodies with simultaneous weakening (of the same kind as that shown to occur by Mikulicz in *genu valgum*, at the epiphysial line of the condyles of femur and tibia), then the unequal pressure produces an unequal bone-formation.

The half which is more strongly pressed upon is retarded in growth, and the vertebral bodies become by this means deformed in a wedge-shaped manner, the base of the wedge being directed towards the convexity of the curve. If the curve caused by deformity of the bone, and become permanent, arises in this manner, then all pressure, even when vertical, of the vertebral column from weight of the upper part of the body will increase it, and the deviation will thus progress in the same manner as we have already learnt is the case in *genu valgum*.

The position of the aorta upon the left side of the vertebral column favours the production of this deformity for, there can be no doubt that, by the position and the pulsations of this great vessel, the left half of the dorsal part of the column is hindered in its growth and its capacity for resistance is lessened, and thus the spine gives way more easily to the increased pressure on the left side, as occurs with weighting of the right arm. The relation is not so simple, however, that we can talk of the aorta pressing the vertebral column to the right by its pulsations. In all cases in which a permanent skoliosis exists, there is either very great one-sided weighting, or else the above-mentioned deficient resisting capacity against unequal pressure in the bone-tissue, or in its epiphysial line of growth. We cannot and dare not avoid this conclusion, for it is just this which forms the keystone to the theory that skoliosis is a weight deformity. Although this abnormality has not hitherto been sufficiently established by autopsies, we must remember that the opportunity of making a post-mortem

examination at an early stage of skoliosis but seldom occurs, and that even then examinations of the vertebral column are seldom made. Nevertheless the strict analogy which skoliosis bears in almost all respects to *genu valgum*, in which this process has been followed out in the most careful manner, speaks in favour of the existence of such an abnormality. This is supported by the fact that the best investigators are of unanimous opinion, that all factors which produce a considerable weakening of the young organism, especially severe fevers, predispose to lateral curvature. Finally we must bear in mind the very much greater proportion in which girls are affected by skoliosis than boys (according to usual computation, this proportion is eight or even ten to one), and especially girls of the 'well to do' classes, whose bony structures frequently show signs of spanæmia and chlorosis.

If, on the other hand, it cannot be denied that even thoroughly strong-looking girls and boys are sometimes affected by skoliosis, without any apparent cause, yet these cases are quite exceptional; and, further, a lessened resisting power of the vertebral column may have easily pre-existed without showing itself by deterioration of the general health. Apart from this, so far hypothetical, weakening of the bony tissue in conjunction with unequal pressure, the weight theory with that of the lateral position of the aorta explains, in a perfectly satisfactory manner, the curve of the dorsal vertebræ with its convexity almost always to the right.[1]

The second curve which in these cases is almost always situated in the lumbar region, with its convexity directed to the left, shows itself to be a compensative curve formed by the muscular action which the patient unconsciously performs in

[1] In sixty-eight of my own patients, nearly all of whom belonged to the 'well to do' class, the characters of the curves were as follows:—Thirty-nine were sigmoid, twenty-nine were single curves, and in two of the latter there was no deflexion of the spinous processes, but rotation only of the vertebræ. Of the thirty-nine sigmoid the dorsal curve was to the right in twenty-seven cases, to the left in twelve cases. Of the single curves, the direction was to the right in fifteen cases, to the left in fourteen cases. That is, in the sigmoid the proportion of right dorsal curve to left was as little more than two to one, and in the single curves the proportion was nearly equal. Of course, further observation may show a different relative proportion, but one cannot now say with correctness that the dorsal curve is almost always to the right.—N.S.

order to preserve an upright position in spite of the disturbed balance.

From the same cause there appears frequently a curve of the upper dorsal and lower cervical vertebræ, which also shows a convexity opposed to the principal curve. With left-handed people, as Béclard has shown from anatomical investigations, even when the aorta remains in the normal position the curve is at times reversed. If, on the other hand, both in right-handed and left-handed people there are a few rare examples of cases in which the convexity of the curve is not directed towards the side of the most generally used arm, these must be regarded as exceptional cases, the explanation of which would very possibly be discovered by a careful examination ; in any case they are much too rare to be offered as proofs against the theory of the effect of the predominant use of one arm upon the direction of the abnormal curve.

Skoliosis does not always begin in the dorsal region ; the first curve almost as frequently commences in the lumbar portion, between the first and third lumbar vertebræ. This curve also has almost always one direction, and that is towards the left. For the explanation of this fixed curve, dependent in its higher degrees upon deformity of the vertebral bodies, we must also look for its first commencement to softness of the bones, and a consequent incapability of resistance to unequal pressure in the manner already described. The uniformity in the direction of this curve cannot always be explained in so satisfactory a manner as in the dorsal curve. Of all physiological conditions the only one which occurs to us as a possible cause is that the patients, when from habit or fatigue they bend one leg and rest upon the other, almost always rest upon the right one. Whether this is really the cause is difficult to establish by observation, but I have remarked that girls who are affected with lumbar skoliosis, when they thought themselves unobserved had a remarkable inclination to stand upon the right leg. However, the explanation of the constancy of direction of the curve in lumbar skoliosis is not so clear as in dorsal skoliosis. In other respects, the same conditions occur as regards the formation of a second, compensatory, curve in the dorsal region.

The question whether skoliosis is an hereditary affection is

a difficult one to answer. One often sees that the children of a skoliotic mother have a faultlessly upright figure, and on the other hand one sees severe skoliosis in children of well-formed parents. But although it not infrequently happens that many members of the same family are afflicted with skoliosis, this may be explained by regarding the lessened resisting capacity of the bony tissue against external influences as the hereditary evil from which the curve is developed from accidental causes.

The theory which places the primary abnormality producing skoliosis in the bone-tissue of the vertebral column itself was originated by Glisson, who, as early as 1650, described it in his book 'De Rhachitide.' Thirty years later Mayow also, in his book 'De Rhachitide,' 1680, attributed skoliosis to the unequal action of the muscles upon a normal vertebral column, and thus created the muscular theory, which has been taken up by Mery (1706), Morgagni (Epistola 27 'De gibbere,' 1761), Pravaz (1827), J. Guérin, and many others; and has found its last offshoot in the *serratus* theory of Stromeyer (1836), Barwell, and Sayre.

Later on, however, Stromeyer, as Little mentions in his 'Deformities,' gave up the serratus theory. In the two centuries which have expired since the publication of these theories, they have been almost ceaselessly discussed in opposition to one another, and even at the present day neither has given way entirely to the other. As the subject now stands, undoubtedly the osseous theory preponderates in the number and importance of its representatives, and it is a justifiable supposition that it will be ultimately adopted. A middle position has been taken up by Delpech, who has looked for the primary change in the intervertebral discs, but this theory has never attained the importance of the other two. However, this last might be worth reviving if one were to substitute for the intervertebral discs the epiphysial cartilages. The other theories which have been put forward for the explanation of skoliosis are not worth mentioning.

Two forms of skoliosis require a particular description: they are the *congenital* and the *rachitic.*

Hereditary or congenital skoliosis is caused either by a congenital deficiency, as, for example, the wedge-shaped develop-

ment of one or more vertebral bodies; or it is the consequence of other serious malformations, especially such as those of the central nervous system, *i.e.* anencephalia, microcephalia, or fissure of the vertebral column, and must in these cases be referred to muscular spasms which are caused by abnormal inervation, or it is a deformity of an originally normal vertebral column caused by intra-uterine pressure, or finally is due to fœtal rickets All these are scientifically very interesting, but have no value in practice, as they either occur in fœtuses, which are incapable of life, or even when this is not the case such deformities cannot be regarded as amenable to treatment.[1] As an example of congenital skoliosis from malformation of the central nervous system, the following case may be recorded :—

Anna Schmidt, the daughter of well-formed parents, was born in the year 1867 with serious deformities. In consequence of these she had never been able to stand upright, but had passed her life hitherto in the horizontal position. Nutrition was normal. At the age of fifteen the patient presented the following appearance :—Extremely small skull, circumference round the external occipital spine and the tuberosities of the frontal bone, 46 cm.; the face was largely developed, especially the jaws, which were furnished with strong teeth; lips much swollen; mouth half open; expression of face stupid; eyes normal. The patient was disposed to senseless laughter, and only rarely cried out from considerable pain; there was not the slightest indication of speech. The head was permanently inclined towards the left shoulder. Thorax tolerably well developed; mammary glands large; abdomen flat; no menstruation. The whole trunk was permanently much bent; corresponding to this was a marked skoliosis with a convexity directed to the right. The greatest prominence of the curve existed directly under the angle of the shoulder-blade. The left arm was relatively well developed, but the movements were very much hindered by muscular tension in all the three joints. The right arm was considerably weaker, and bent to a maximum at the elbow and the wrist. It required considerable strength to stretch the contracted flexors, and it was impossible to straighten the wrist entirely. For active movements the patient availed herself exclusively of the left arm, and performed by its means slow, but to some extent effective,

[1] A very valuable paper upon congenital malformation of the spinal column, by Messrs. Willett and Walsham, is to be found in the *Medico-Chirurgical Transactions*, vol. lxiii.—N. S.

movements. Urine and alvine evacuations were passed in bed. The left leg was also decidedly better developed than the right, not only in the muscles, but also in the mobility of the joints. The left hip joint was flexed, adducted, and rotated inwards; the knee slightly flexed; the foot in the equinus position, but it was possible to straighten all three joints by means of considerable force. In the right leg the hip and knee joints were slightly flexed; the foot in severe varus position with a slight degree of equinus. Extension was possible in the two first joints, but the power of hand was not sufficient to reduce the foot to a normal position.

In this case it is clear that skoliosis cannot have arisen from weight, as pressure upon the vertebral column by the weight of the body had never occurred. The muscular tension in the extremities, which has often brought the joints into positions which are opposed to weight, does *not* allow us to attribute the skoliosis to a muscular cause. The cause of these rigid muscular contractions is undoubtedly the serious malformation of the central nervous system, which with respect to the brain may clearly be proved by the smallness of the skull, and probably the spinal marrow was also affected, though external examination gave no direct evidence of this.

Rachitic skoliosis in early childhood generally occurs in those cases in which rickets has involved a great number of bones. It also happens, as I have seen in many cases of this kind, that the vertebral column is the chief site of the softening with only slight participation of the rest of the skeleton.

Deformity of the vertebral column occurs here in the same manner as in the bones of the extremities, *i.e.* almost entirely from weight, with only slight participation of muscular contraction. Accidental conditions, such as carrying weights upon the right or left arm, lying upon the right or left side, determine whether the lateral curve shall have its convexity to the right or to the left. As regards the internal organisation of the body, there is no reason which would explain the direction, corresponding with which fact the regularity in the direction of the curve which is so characteristic of skoliosis in later childhood is absent in rickety skoliosis. The curve to the left occurs just as frequently as the curve to the right.

In thirteen cases of rickety skoliosis of which I have

records, eight showed the convexity of the dorsal curve to the left, and five to the right. The small difference between these figures is caused by the small number of observations, and is thus accidental; in any case, however, one can see from these numbers that in rickety skoliosis there is no particular tendency for the dorsal curve to be directed to the right. Children with rickety spines are at the mercy of extraneous circumstances, by which alone the direction of the curve is determined. Neither does rickety skoliosis predominate in the female sex. As rickets itself shows no such predilection, neither does the curve which is dependent upon it.

The thirteen cases mentioned above consist of eight girls and five boys, and this slight difference is undoubtedly accidental.

It is almost always the dorsal position which is curved, because this is the middle of the spinal column, and therefore the spine, like a rod, is more easily bent in this part. When there is a curve in the lumbar region in the opposite direction, it is quite insignificant in comparison to the dorsal curve.

In one essential particular rickety curvatures of the vertebral column are distinguished from similar curvatures of the bones of the extremities, in that they never retrograde, but rather increase in the course of further growth. The reason of this difference is that the vertebral column is made up of a large number of single bones; the surfaces of apposition are under much more unfavourable conditions than the epiphyses of the long bones. Therefore, all the deformities of the rest of the skeleton in early life have completely retrograded in the course of time, whilst the deformity of the vertebral column continues in unchanged or even in an increased degree. There is certainly one bony mass which shares the fate of the vertebral column in not being able to repair its rickety deformity, and that is the pelvis; and as this is always affected, we are always justified in assuming that the pelvis is deformed in girls suffering from rickety skoliosis, and therefore in giving an unfavourable prognosis in respect to parturition in after-life.

Pathological Anatomy of Skoliosis.—The ordinary fixed skoliosis caused by deformity of the bones shows (with rare exceptions) a double or even a still more complicated curve;

rickety skoliosis on the other hand is often simple from the beginning, and remains so. If ordinary skoliosis (*sigmoid*) increases in the course of years to a considerable degree, it often happens that it becomes a single curve. The principal curve, which is generally the dorsal, so increases as to involve the lower and any upper curve that may be present. If in such a case we stretch a thread from the tip of the spinous process of the seventh cervical vertebra to the middle of the sacrum, the row of the spinous processes deviates from it only towards one side. Now, if in these cases we let fall a plummet from the external occipital spine, this touches the sacrum far to the right of its middle line.[1] The whole upper part of the body is then pushed considerably to the right in relation to the pelvic base. If the lumbar curve predominates from the beginning, then it but seldom reaches this highest grade of skoliotic curve.

In considering carefully the changes which the vertebræ undergo in the course of skoliosis, it is desirable to look upon the vertebral column as divided into two parts: an anterior, consisting of the bodies, the intervertebral discs, and the longitudinal ligaments; and a posterior, consisting of the arches, the processes, the ligaments, and the muscles.

In new-born infants the majority of the vertebræ contain three osseous centres, one in the middle of the cartilage for each body, and two for each arch uniting in the middle line posteriorly. The atlas contains only two centres, for the nucleus of its body coalesces with the body of the axis, and thus forms the odontoid process. The bony union of the arches occurs from the first to the third year, at first in the dorsal and lower cervical, then in the lumbar, and finally in the atlas.

At the time of puberty small bony centres are found at the tips of all the spinous and transverse processes. In the course of growth an upper and lower independent bone nucleus develops in the cartilaginous substance of the vertebral bodies, which nuclei at puberty have enlarged so that they include the whole width of the body, and are divided from the central bony

[1] In these cases the first results of mechanical treatment is to produce the sigmoid form, showing that the supposed change to a single curve is more apparent than real.—N. S.

portion by epiphysial cartilaginous discs. The axis contains only one such cartilaginous disc, the atlas none. The complete coalescence of these divided bony centres is very gradually perfected, and is only ended when the body ceases to grow in height, that is, about the twenty-third to the twenty-fifth year.

Now the *vertebral bodies* undergo the most serious deformity in skoliosis. Under the unequal pressure to which they are subjected, the side towards the concavity of the curve is considerably retarded in growth, whilst the opposite side develops normally. The consequence of this unequal growth is a wedge-shaped formation of the vertebral bodies, the edge of the wedge being directed towards the concavity. The most deformed is the body of that vertebra which forms the most prominent part of the principal curve. And gradually from this point the deformity subsides upwards and downwards. If there is a secondary lumbar curve below the dorsal, that vertebra which forms the junction between the two curves shows no deformity. The vertebræ more deeply situated display, though in a small degree, the wedge-shaped formation, and according to the direction of the curve the edge of the wedge is directed to the opposite side. By reason of this unequal bone-formation, the vertebral bodies become in a high degree asymmetrical, and also the arches with their spinous processes become very much changed in form in consequence of the perfectly altered conditions as to traction and pressure. But besides this asymmetry a rotation exists, which gives the vertebral bodies a direction towards the convexity of the curve, whilst the spinous processes are turned towards the concavity. If we wish to determine the angle, round which each single vertebral body is twisted about its vertical axis, we must be able to define precisely that place on its anterior surface which was the middle line before the appearance of the curvature. This determination, however, is almost impossible from the asymmetry of the bodies which has developed in the course of years; indeed, it cannot be made with the requisite accuracy. If, for example, we judge the middle of the vertebral body from the spinous process, we shall find ourselves in error, as the spinous process itself has deviated very much from its original direction.

Nicoladoni,[1] who has pointed out this difficulty, tried to utilise the anterior longitudinal ligament as a means of finding the original middle line. He found that the fibres of this ligament are in skoliotic vertebræ very unequally divided, as they are sparse and separated from one another on the side turned towards the convexity, whereas on the side of the concavity they are very close and thick. He could not therefore divide the breadth of the ligament into two equal parts, but made a division depending upon calculation of the approximately equal number of filaments, which division fell at a point between the two-thirds turned towards the convexity and the one-third turned to the concavity. This place he believed to indicate the original middle before the commencement of the curve, and from this standpoint he contended that the skoliotic vertebral column appeared to show a torsion of the vertebra but that the whole appearances could be referred to asymmetrical bone-growth. It is easy to show that the middle line assumed by Nicoladoni is not the right one. Insertions of fibrous tissue into bones cannot be regarded as fixed points; they alter in the course of growth, as was undoubtedly established in the discussion on bone-growth, but they alter still quicker under abnormal traction, as is the case to a very great degree in the course of skoliosis. Nicoladoni might have been able to perceive from the unequal division of the fibres of the ligament on the front surface of the vertebral bodies that here great changes had occurred, which made the relations quite unsuitable for the determination of the original middle point. Under these circumstances it is unfortunately quite impossible to determine in asymmetrical vertebral bodies the point where the original centre existed, and therefore the torsion angle of the separate bodies cannot be exactly determined. Careful examination of a very skoliotic vertebral column is, however, always sufficient to show that together with the asymmetry caused by the retarded growth, no inconsiderable degree of torsion is present, which essentially assists in the increase of the curve. Now the question which used to be asked for explanation of this torsion was this, 'What muscles produce the torsion?'

[1] *Die Torsion der skoliotischen Wirbelsäule.* Stuttgart, 1882.

The question, however, is not rightly framed; it should be rather, 'What mechanical conditions cause the torsion?'

We must recollect in the first place that every lateral curve of a normal vertebral column is accompanied by a slight degree of torsion. The reason of this consists on the one hand, as Swagermann perceived so far back as 1767, and as Henke quite recently emphasised, in the position of the oblique processes which do not permit a purely lateral curvature to occur; and on the other hand in the great inequality between the anterior and posterior parts of the vertebral column. The bodies joined together by the thick intervertebral discs may be more easily pushed aside than the arches, which are very closely fastened by the short tense ligaments. Now as the bodies which alone bear the weight are mainly subjected to deviating and deforming influences, it is intelligible that they should present a greater deviation than the arches; in other words, that the middle line of the bodies should be directed to the convexity, and the line of the spinous processes on the other hand to the concavity. In this way the first slight torsion of the vertebral bodies arises. Now if under the influence of the unequal pressure an unequal bone-growth has set in, then the vertebral body lies no longer between two horizontal surfaces, but between two planes inclined towards one another; and these push it, under the influence of the weight of the upper portion of the body, towards the open part of the angle, and thus increase the torsion. The weight forces the vertebral bodies situated between the oblique planes to a certain degree out of the row of the upper ones. Thus asymmetry of growth and torsion increase each other, but both are real processes throughout, and not merely apparent processes. Through the combined influence of rotation and asymmetry the curve is often increased to a right-angled position of the vertebral column, in which the point of the angle is formed by the most deformed and twisted vertebra.

These cases are often designated as *kypho-skolioses.* The connection of these two words is, however, calculated to cause confusion. We had reserved the term kyphosis exclusively for the deformities of the column caused by spondylitis, and cannot, therefore, consider such an association of words suitable.

If we would select a special term for this condition we might indicate it as *scoliosis gravissima* or *rectangularis*.

As for the further changes which a very skoliotic vertebral column suffers, it is to be pointed out that the edges of the vertebral bodies which are most deformed roll up, precisely as if the bone-tissue when in a soft condition was forced by pressure over the free border and then hardened. This appearance is deceptive; the process is really otherwise. The bone-tissue from pressure arrives at a condition of irritated hyperplasia which appears most distinctly at the edges. The intervertebral foramina preserve generally their normal width; sometimes they are widened at the convexity of the curve, but only rarely narrowed at the concave side. As the vertebræ are subjected to very severe pressure against one another, points, normally in contact, are no longer so, and other points, normally separated, come into contact. Thus it happens that old joints become obliterated because the joint surfaces are now permanently separated from one another, and new joints form in which two bone-points permanently act upon one another by pressure and friction. Thus the rough bone-surfaces become polished, covered with a rudimentary but still tolerably smooth cartilaginous covering, coalesce at the edges by means of connective tissue adhesions, which then undertake completely the functions of a closed articular capsule, and the hollow enclosed by these becomes filled with a fluid, which is very similar to the normal synovia. But in the course of time such joints may again disappear in consequence of cartilaginous or bony ankylosis. Thus in the course of years bony union takes place between a great number of vertebræ; indeed, even an entire skoliotic vertebral column may by this process be changed into one undivided bony mass.

As the vertebral column forms the foundation of the trunk, its deformity reacts upon all the bones which are connected with it. First of all the ribs. On the side of the convexity of the curve the ribs become separated from one another, and are crowded together on the concave side. Besides this moreover the curve of the ribs is very much altered. The posterior curvature of the ribs on the convex side is very much increased; the anterior curvature, however, where they are

attached to the sternum, approximates a straight line. The reverse is the case on the concave side of the curve. This alteration of the ribs reacts again upon those bones which are supported upon them, namely, the shoulder-blades and the sternum. The shoulder-blade on the convex side is pushed upwards and backwards by the increased backward curve of the ribs; hence the common name of 'high shoulder' for this stage of skoliosis; the shoulder-blade on the other side, on the contrary, loses its support from the alteration in the posterior curve of the ribs, and sinks inwards, corresponding to the degree of its flattening. At the front surface of the thorax the neighbourhood of the costal cartilages appears flattened on the

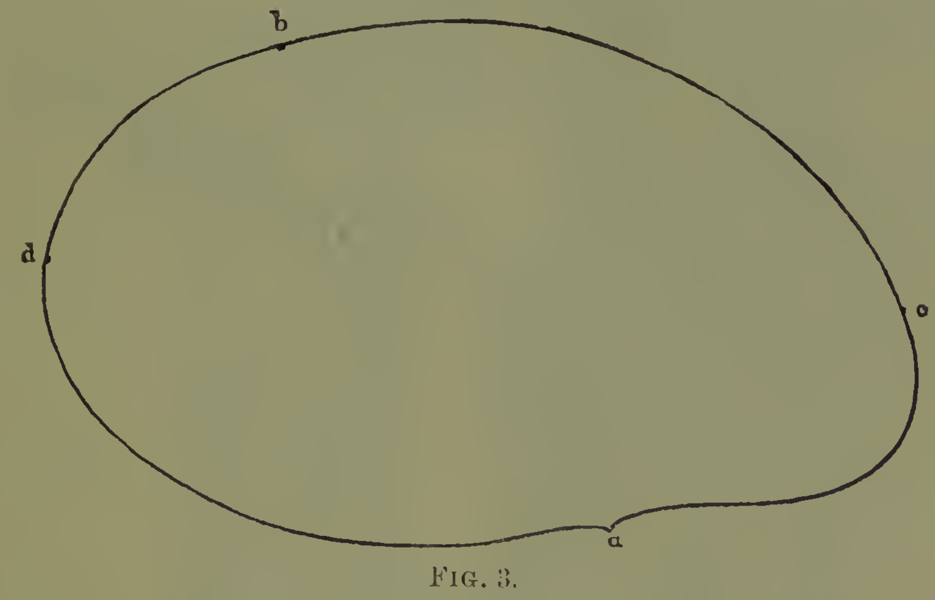


FIG. 3.

a, spinous process; *b*, middle of the sternum; *c*, convexity; *d*, concavity.

convex and raised on the concave side. Thus opposite conditions on either side occur; the protrusion of the ribs backwards upon the side of the convexity is responded to by an anterior projection on the side of the concavity. In consequence of these displacements the sternum is pressed out of the middle line and occupies a position towards the concave side from above downwards.

The resulting severe thoracic asymmetry is shown clearly in the accompanying section, which was taken at the level of the xyphoid process with the help of lead tubing from a case of very severe skoliosis in a girl fifteen years old. The thoracic cavity is very considerably contracted by these alterations in

its walls, and the constriction is principally vertical in consequence of the shortening of the vertebral column caused by the curvature. In width the cavity does not lose essentially, for what the oblique diameter loses from the left and posteriorly to the right and anteriorly, the other oblique diameter conversely gains.

The usual assumption also, that the half of the chest corresponding to the convexity is more voluminous than the opposite half, is entirely wrong; for here, too, it appears that

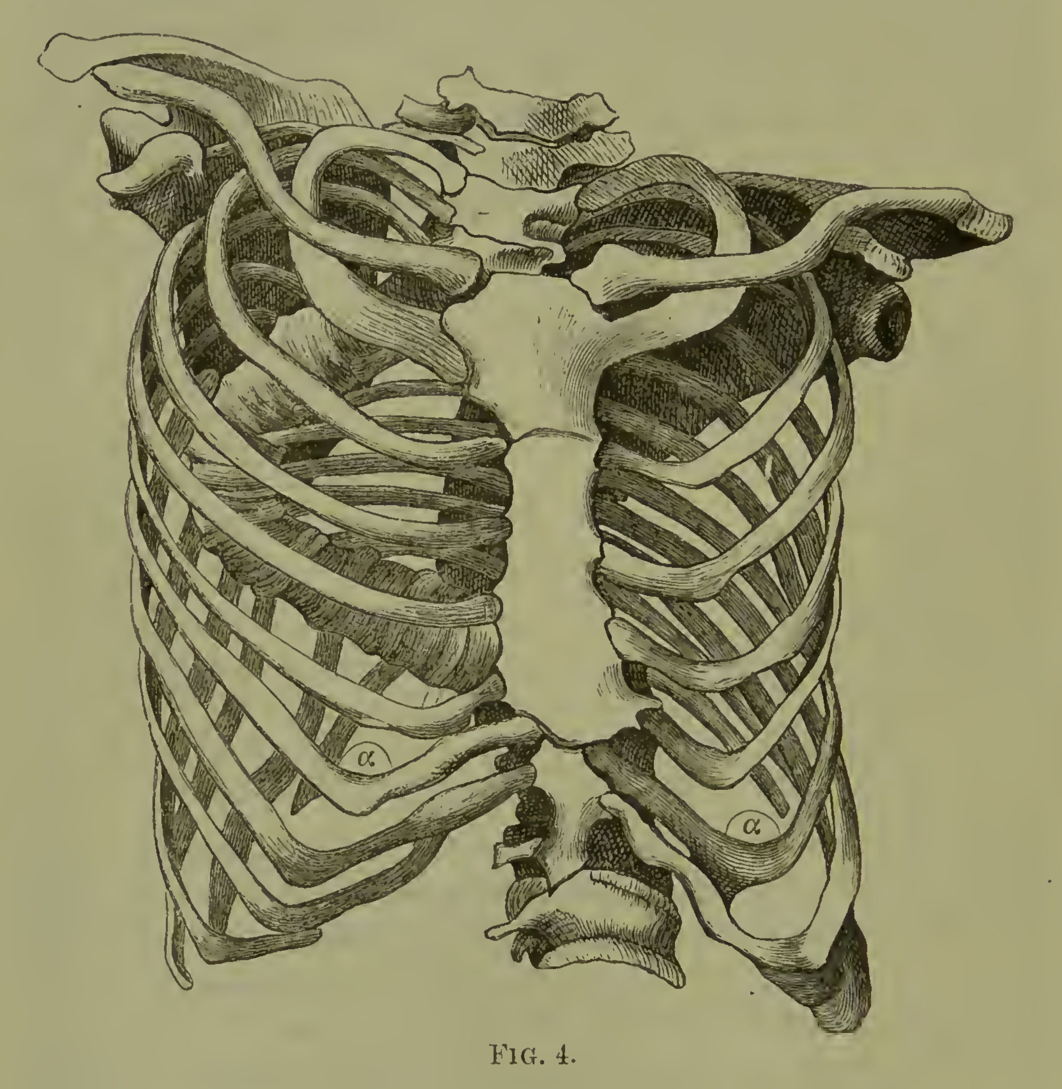


FIG. 4.

the excess of the one half over the other posteriorly is lost again anteriorly. The great projection of a skoliotic column is especially deceptive in this respect. This projection is for the most part not filled with pulmonary tissue, but by the vertebral bodies. For by the torsion the vertebral bodies always approach more nearly to the inner surface of the ribs corresponding to

the convexity; and in high degrees of the curve the front surface of the vertebral bodies is applied for some distance to the inner aspect of the ribs. The laterally deviated and twisted vertebral bodies gradually draw the ribs of the convex side round them as the thread is wound round the spool. See the illustration of a skoliotic thorax after Henke, fig. 4.

Hence it is that the large projection of the humpback is to a great extent filled with the laterally pressed and twisted vertebral bodies. Ribs and vertebræ may finally be connected at the points of contact by accidental joints, or they may undergo bony coalescence, just as the ribs on the side of the concavity do when pressed together.

If the skoliosis principally affects the lumbar vertebral column, the abdominal cavity is contracted from above downwards and the diaphragm is pressed upwards. Here, too, the torsion of the vertebræ makes itself clearly perceptible by the backwardly rotated transverse processes of the convex side raising the mass of the sacro-lumbalis muscles upwards, whilst the mass of muscles on the concave side sinks in because it loses its natural support by the forward rotation of the transverse processes of the vertebræ on this side. The more the shortening of the lumbar vertebral column from curvature occurs, so much the deeper do the lower ribs sink until they push against the crest of the ilium, or, passing this crest, lie deeply in the iliac fossa. The pelvis in general suffers no great deformity in skoliosis. Precise measurements indeed show clear signs of asymmetrical formation of these bones, but the deformity is seldom so important as to cause a hindrance to parturition. If the shortening of the abdominal cavity from the curve of the lumbar vertebral column is not so considerable as to cause restriction of space for the normal development of the pregnant uterus, skoliotic women may pass through several pregnancies without serious danger. An exception, however, must be made in the case of rachitic skoliosis, already mentioned, dating from earliest childhood, in which severe pelvic deformity is almost always present, and causes a serious hindrance to parturition.

Thus there is by no means the close connection between deformity of the pelvis and that of the vertebral column which one might be disposed to assume. The most serious forms of

the obliquely contracted pelvis which Nägele describes had not led to skoliosis; on the other hand very serious (not rachitic) skoliosis may exist without causing any considerable malformation of the pelvis. It is often asserted that the pelvis in skoliosis is rotated about its vertical axis, so that when looking at the front surface of the body the one anterior superior spine is nearer to the spectator than the other. For the decision of this question it is necessary to determine what part of the front surface of the body we should take as our guide for this judgment. If we choose the sternum and place ourselves opposite to the patient, so as to be directly in front of this bone, then, in fact, one anterior superior spine does project more than the other; if, on the other hand, we place the patient straight before us, with the feet together and the knees pressed together, then both spines are at the same distance from the spectator; on the other hand the upper part of the trunk appears twisted as regards the pelvis, so that the shoulder corresponding to the convexity of the dorsal curve lies further forward. But as a symmetrical basis is a necessary requirement for judgment as to the presence of rotation, we must not say that the pelvis is rotated about its vertical axis, but that upon the basis of the symmetrical pelvis the upper part of the body is rotated about its vertical axis. There is, however, a constant rotation of the pelvis, but it is about its transverse axis. As every projection forwards of the vertebral column is followed by an increased pelvic rotation, so every diminution of the lumbar curve leads to diminution of that rotation. The inlet of the pelvis approximates to the horizontal. Now as every skoliotic curve of the lumbar vertebral column assumes in the course of time from rotation a backward tendency, which changes the normal lordosis into a curve in the opposite direction, so we also always find in these cases a rotation backwards of the pelvis, corresponding *pari passu* to the degree of the backward lumbar curve.

In the skulls of individuals with severe skoliosis Sterne[1] found no great deviation from the normal. So long as skoliotic people are able to hold their heads upright there is no cause for unequal skull-development. If, on the other hand, the skoliosis is so great as to cause the head to be permanently

[1] Sterne, *Müller's Archives*, 1834, iii.

sunk on one side, especially when this occurs before the end of bone-growth, then marked asymmetry in the skull can hardly be absent. However the cases are very rare in which skoliosis attains such a degree as to cause the head to sink upon one side.

The extreme length of the extremities in crippled people is often referred to; it is, however, only the disproportion between the length of the extremities and that of the body which strikes the eye. The extremities are not abnormally long, but the trunk is abnormally short; the bones of the legs not being diseased have attained their normal length; the trunk, on the other hand, from its support, the vertebral column, being bent, has remained too short.

In all cases of severe skoliosis the muscles of the back, both at the convexity and at the concavity, are thin, pallid, and when examined microscopically appear fatty. This is the simple consequence of a skoliotic trunk almost completely losing its power of movement from the pressing together of all its bones, its muscles being much less used. In cases of commencing skoliosis in youth, in which precise examination has been made *post mortem*, the muscles situated at the convexity appeared more atrophied than those at the concavity. This only proves that the muscles of the convex side are placed under more unfavourable circumstances than are those of the concave.

The latter become shortened as their origins and insertions are approximated, and only gradually become disused; while the former are lengthened by the separation of their origins and insertions, and are stretched tightly over the protruding bones, whereby they degenerate still more quickly. These facts afford no basis at all for a theory of a muscular cause for skoliosis. Bouvier made a very conclusive experiment, in opposition to the theory that the muscles have a great influence in the production of skoliosis. He hung, directly after death, the body of a girl twenty-four years old afflicted with skoliosis, by the head, with a considerable weight attached to the feet, and carefully measured the length. Then he divided singly all the muscles which one could possibly suppose capable of preserving the curve by their contraction.

No lengthening of the body resulted; affording a clear proof

that the curve was exclusively caused by the form of the bones held together by the ligaments.[1]

The alteration in shape of the bony walls is very serious, and naturally reacts upon the thoracic and abdominal viscera, which are thus compressed and displaced.

The vertebral canal follows the curve of the vertebral column and keeps about midway between the curve of the bodies and of the spinous processes. The spinal marrow follows the curve of the vertebral canal, though in a somewhat lesser degree as, on account of the mobility which the cerebro-spinal fluid allows, it follows the curves in a somewhat shortened route. Where the cord is adjacent to the convexity of the principal curve it is often somewhat flattened but without any very marked change. As a rule the spinal marrow accommodates itself very well to these alterations in position, taking place as they do gradually during several years, so that it is very rare for disturbances of mobility or sensibility to occur from disease of the spinal marrow in these cases. On the other hand the intercostal nerves are often compressed and displaced upon the side of the concavity of the curve from the approximation of the ribs, a fact which explains the intercostal neuralgia from which severely skoliotic people so often suffer in old age.

[1] 'Mr. John Shaw found, upon dissection, that the muscles had atrophied upon the concave side, and he also found the nerves that supplied these muscles "diminished to less than one half their natural size"—a condition which he supposed depended upon the atrophied condition of the muscles.

'Mr. Gay dissected a case of severe lateral curvature in the cervical and upper dorsal vertebræ, convex to the left, in a young woman, aged 23, who died from fever. The muscles of the chest, both before and behind, were very feebly developed and pale. "The intercostals of the left side had lost the usual characteristics of muscular tissue"—were degenerated to a mere membranous expansion. The sacro-lumbalis and longissimus dorsi on both sides were "comparatively large and powerful." The abdominal muscles were large, but partook of "the general feebleness of the integral structure." The diaphragm was very powerful. Attempts to straighten the spine at this stage of the dissection caused the lumbar fascia to become tense and resistant. That fascia, being divided transversely, extension caused only a separation of the cut fibres, to the extent of half an inch. Although all the muscles were removed, no manual force could straighten the spine. The intervertebral fibro-cartilages were thinned on the concave and thickened upon the convex side of the spine; their elasticity was lost.'—*Surgery of Deformities*, by Noble Smith, p. 176.—N. S.

The displacement of the vertebral column and sternum modifies the shape of the thoracic cavity, and thus alters the position of the lungs and heart. The heart at first bears very considerable displacement without harm, the mechanism of its valves does not suffer, but when the patient attains to old age the muscular substance, in cases of severe skoliosis, usually becomes pallid, relaxed, and easily torn. The lungs also adapt themselves at first very well to the altered conditions of the thorax. They thus accommodate themselves to the alteration, their volume being reduced correspondingly to the diminution of space in the thorax, and they act in a sufficiently effective manner for the requirements of ordinary life. The most essential or almost the only respiratory muscle in skoliotic people is the diaphragm, as the expansion of the thorax by the raising of the ribs does not take place. This muscle, however, suffers considerably in its power of action from the asymmetry of its attachment to the altered thoracic walls.

Since the days of Morgagni we know that the aorta follows the curves of the vertebral column, as also do the venæ azygos and cava inferior. The œsophagus, on the other hand, leaves the vertebral column, and passes from the pharynx vertically downwards to the œsophageal foramen of the diaphragm. Corresponding to the approximation of these two points, it shortens considerably in its substance, and forms no folds or projections. The stomach and intestines are pushed aside and compressed, but are not much displaced ; the liver almost always shows deep impressions of the depressed lower ribs, and is generally diminished in size; the spleen is small and atrophied, sometimes displaced into the fossa iliaca; the kidneys, too, are pushed aside and compressed, especially in lumbar skoliosis.

Symtomatology of Skoliosis.—The symptoms which are produced by skoliosis depend essentially upon the degree of the disease. Although no clear divisions can be made between the slightest curvature passing gradually into the most severe, yet for better comprehension we will describe three degrees of the affection. *In the first degree* the commencing symptoms of curvature only show themselves on careful examination ; *in the second degree* the curve is clearly marked out, so that it is recognised at the first glance when the back is bared ; and

finally, *in the third degree*, the curve has increased to an undoubted humpback.

A skoliosis *of the first degree* is very difficult to recognise, because here the line of the spinous processes is still perfectly straight. But by means of torsion the vertebral bodies may be already considerably displaced. We perceive this from the inequality of the two sides. Thus in ordinary skoliosis there is found a slight projection of the right ribs, by which the right shoulder-blade is pushed a little upwards and backwards, and the side contour of the right half of the thorax shows a somewhat fuller curve than that of the left, which is especially noticeable in the lower thoracic region. The ribs of the left side of the back are, on the contrary, somewhat flattened and the shoulder-blade in consequence lies somewhat lower than the right; also the lines which pass from the neck to the shoulder show on the two sides (when carefully compared) a slight dissimilarity. Upon the front surface of the thorax there are no differences to be remarked, as a rule, but sometimes the region of the rib cartilages on the left is a little more prominent than on the other side. In the lumbar region the mass of the left sacrolumbalis muscle is somewhat pushed upwards, and is clearly firmer and harder than the right. The left iliac crest only slightly projects, because the vertebral column, bending towards the left, carries with it the soft parts; the right iliac crest, on the other hand, forms a distinct prominence, because the soft parts covering it are drawn somewhat towards the deviating vertebral column. This difference in the lumbar and pelvic regions will not easily escape a practised eye. Crossing the arms over the chest in order to remove the shoulder-blades farther from the vertebral column, and bending the body, certainly allow the line of the spinous processes to protrude more clearly, but they also diminish the lateral inequalities.

Since in these cases the line of the spinous processes shows no deviation, this method of examination, which is so frequently had recourse to, is not especially suitable for the diagnosis of incipient skoliosis. The prone position makes no real difference, but the lateral dissimilarity is not so much marked as in the upright position; and thus this position is equally unfitted for our recognition of slight degrees of skoliosis. Now

as both halves of the back are seldom, or perhaps never, perfectly symmetrical, it is difficult to diagnose early skoliosis from these small differences. Nevertheless, we can hardly err if we find that the right side of the dorsal and the left side of the lumbar region are somewhat raised, whilst the opposite sides are slightly lowered.

In *the second* degree the line of the spinous processes already exhibits a distinct deviation. We see this through the skin, but we also feel it when we draw the hand down over the back, with the tips of the second and third fingers pressed firmly together in such a manner that the spinous processes are between the finger-tips. If we repeat this stroking several times a pale streak remains over the spinous processes, which marks the curve, whilst the parts pressed on become red. The right ribs now project distinctly backwards, and make the shoulder-blade prominent; the left ribs are much depressed, and the shoulder-blade correspondingly fallen in; the upper shoulder line is higher at the right than at the left. However, it sometimes happens that the left shoulder-blade is the higher, and especially when, with increase of the dorsal curvature, an opposite compensation curve has already developed, which again projects the uppermost ribs on its own side. On the anterior surface of the thorax the region of the left costal cartilages is distinctly prominent, and in severe cases the sternum has already left the middle line, and has taken a direction from right to left from above downwards. In the lumbar region the left sacro-lumbalis muscle is distinctly prominent and hard to the touch; the corresponding muscle on the right is, on the other hand, sunken, the right crest of the ilium clearly protrudes, and above it is to be seen an obliquely coursing cutaneous fold; the left, on the other hand, is concealed by the soft parts, which are pushed over it. Unilateral curvature, which is seldom to be met with, even in the first degree, is hardly ever found in the second; but almost always either the dorsal or the lumbar curve is the more clearly expressed, and in about equal frequency in either case. If the dorsal curve preponderates, the position of the pelvis needs no special attention; but if the lumbar curve is the more pronounced, we must always observe carefully whether the side of the pelvis corresponding to the convexity of this

curve is not somewhat lower than the other ; a condition which can only be the consequence of a shortening of the left leg.[1] Such real shortening, when proved to exist, is of great importance, as by its compensation the pelvis is made horizontal, so that the vertebral column can rise perpendicularly upon it. For proof of this we may strip the patient, place him in the horizontal position, and then measure with a tape from the anterior superior spine on each side to the outer malleolus ; yet this method is not very reliable, as, apart from the inconvenience with which it is attended, it gives no certain results. It is better while the feet are closed and the knees pressed together, to let fall an ordinary plumb-line from the anterior superior spine of the ilium, and to compare the length on either side, or else to let the patient hang by the hands from a horizontal bar, and then to observe whether the feet are level.

The most effective method of measuring appears to me to be the following :—A perfectly flat board with a semicircular piece cut out bears a small spirit-level. Two points of the section are now placed against two corresponding points of the pelvis, and the air-bubble of the spirit-level shows whether one side lies lower than the other. If we seat a patient affected with decided inequality of the legs upon a horizontal surface, the lumbar curve is at once diminished, as now the legs have no influence and the body is supported directly upon the horizontal surface by the tuberosities of the ischium. The following case may serve as an example :—

Martha K——, aged nine, was attacked in her fourth year with periostitis of the right tibia, which produced suppuration and shedding of a small sequestrum, and which finally healed up, after a year and a half, with a cicatrix involving the bone. In the ninth year the mother remarked, for the first time, a curve of the vertebral column, which had already reached a tolerably high grade. Examination of the child, whose height was 116 cm., showed in the lumbar portion of the vertebral column a severe curve, with its convexity to the left, and a smaller compensating dorsal curve. It struck me at once that the left side of the pelvis was considerably lower than the right, and careful measurement gave 2 cm. of difference. Raising the left

[1] I have met with cases in which one side of the pelvis was abnormally smaller than the other.—N. S.

half of the pelvis to this extent caused the curve to disappear almost completely. Measurement of the leg proved that the previously affected tibia was 1½ cm. longer than the sound one, so that the lower position of the left half of the pelvis was thus entirely or at least for the most part explained.

The dorsal curve of the second grade is at times made to disappear by exerting strong pressure with the right hand against the right side of the thorax whilst we make a counter-pressure with the knee at the level of the left half of the pelvis and with the left hand in the left axilla. If we wish to determine the intensity of the curve, we stretch a thread from the tip of the spinous process of the seventh cervical vertebra to the middle of the base of the sacrum, then we notice the vertebra upon which the thread cuts the line of spinous processes; and thus we find the place of union between the two curves. Above and below this vertebra we distinguish the degree of curvature by the direction of the thread. Yet we must always remember that we have not found by this the real curve of the vertebral bodies because the latter is always more considerable than the curve of the spinous processes.

Curves of this grade are mostly still perpendicular, *i.e.* the plummet let fall from the external occipital spine still touches the middle of the base of the sacrum; yet sometimes it may fall to a certain degree away from it. The horizontal position on the abdomen does not materially diminish the curves, but the vertical suspension of the body by a collar supporting the chin and the back of the head always effects a diminution and sometimes removes the curve completely.

In the third grade that curve which in the second grade was the principal one now absorbs the other curve, and thus forms so great a prominence that the name of humpback may now be suitably applied to it. The perpendicular plummet-line let fall from the external occipital spine now always lies to one side of the middle of the sacrum, as the whole body is bent to one side. The correction of the curve can now be no longer made by strong pressure of the hands, and even vertical suspension does not diminish it much. As to the lumbar curve there exists in the left lumbar region a considerable bony pro-

minence directed backwards and to the left, the left crest of the ilium is quite covered, the right protrudes considerably, the lower ribs on both sides lie deep in the fossa iliaca. In the case of the dorsal curve there exists on the right side a great bony prominence, convex backwards and to the right, which projects the shoulder-blade backwards and outwards, or in the most severe cases may even displace it externally, and project above its upper margin. On the front of the thorax, too, great inequality is also to be found.

It is not every case of skoliosis which passes through all three grades. The affection may remain stationary in any stage, but even in the slightest skoliosis of a girl from ten to twelve years of age it is very difficult, nay, almost impossible, to predict how the deformity may alter later on. Some unfortunate cases (even in youth) pass through all these grades in the course of a very few years, probably because the bones are very soft. In most cases, however, in which clear signs of skoliosis exist it ceases to increase at the beginning of the twentieth year of age, when growth in height is about completed, either in the stage of high shoulder or of high hip, which may still be hidden by external coverings. Nevertheless this halt in progress is by no means permanent. If the girl marries we often observe that she becomes more deformed after every parturition, especially if she goes through a great number. Pregnancy and childbirth have often, as the history of puerperal osteomalacia shows, a weakening effect upon the bones; and when the vertebral column has already deviated from the middle line, this effect shows itself in cases which would otherwise be unaffected by it.

In old age every skoliosis increases, and often to a frightful extent. Senile softening, which causes even the straightest vertebral column to sink, allows deformity to occur to a much greater extent when skoliosis already exists. Privation, trouble, and anxiety may also add to the effect of age.

The results which skoliosis produces upon the general health differ greatly according to its degree. The first grade can only be considered as a slight abnormality, it is attended with no disturbances, and even the outer form of the clothed body may appear perfect. The second grade always produces defect

in the symmetry of the external appearance, which, even when the inequality of the two sides is removed, still at once strikes the practised eye, even through the clothes, on account of the shortening of the upper part of the body, the great projection of the back, and the large circumference of the waist. Otherwise this grade does not cause much disturbance. Skoliotic girls are certainly very often chlorotic, menstruation is delayed and irregular, but it is doubtful if these disturbances are to be regarded as causes or effects of skoliosis. The third grade always causes bad results to the general health by interfering with respiration and circulation. The diminished breathing surface of the compressed lungs compels a superficial and rapid respiration, which although sufficient for the occupations of ordinary life quickly becomes insufficient during severer efforts, such as running, mounting stairs, &c. and is even barely sufficient for loud speaking or singing.

Exceptional cases, however, occur in which skoliotic people develop a remarkably high degree of bodily strength. I once saw a man, formerly a joiner, forty-eight years old, with a severe skoliosis and progressive muscular atrophy, lying helpless in the hospital, who stated that from his twentieth to his thirtieth year, although even then his right shoulder was very much protruded, he had possessed a high degree of strength. He had been able to lift a hundredweight with the little finger of either hand, and in carrying heavy pianofortes he had with his prominent shoulder lifted quite five hundredweight. Victor Hugo, therefore, does not err when he ascribes to Quasimodo, who is affected with congenital skoliosis, enormous bodily strength. Skoliotic people often suffer from palpitations and other irregularities of the action of the heart, and the small, flabby heart is generally unable to propel the blood through the body with the necessary energy in consequence of the abnormal resistance caused by the twisted course of the aorta. Venous stasis is consequently an influential factor in the diseases of humpbacks, in which, apart from the cardiac weakness, the circuitous course of the great veins and the diminished strength with which the lungs are able to aspirate in returning venous blood, come into consideration. These conditions moreover explain the great disposition of these people to fainting, con-

gestion of the brain, and even apoplexy, which results do not arise, as Morgagni (Epistola iv.) believed, from the closer proximity of the heart and brain, but are due to the shortening of the vertebral column. In the same way also is explained the almost perfect immunity from tuberculosis of the lungs enjoyed by badly skoliotic people. However unfavourable may be the respiratory conditions, however compressed and displaced the lungs, they are extremely seldom attacked by tuberculosis. This peculiarity is explained by the great venous congestion in the lungs, and congested organs are almost certainly protected against tuberculosis.

According to the parasitic theory one would therefore say they do not present a favourable nutritive ground for the development of tubercle bacteria. Percussion and auscultation are of very little use for the recognition of diseases of the lungs, as the great dissimilarity of both sides excludes all comparisons.

The numerous misplacements which the bones as well as the internal organs undergo lead to distortions, which give rise to violent pains. Intercostal neuralgia especially causes great suffering in old age to humpbacked people. As a rule, it occurs on the concave side, where the ribs press against each other. Appetite and digestion are not in general much disturbed, but the space for the diminished stomach only allows that organ to receive a small quantity of food, and, in consequence of this, humpbacked people are generally very thin. With regard to the liver, the spleen, and the kidneys, no disturbances occur. We often find great intelligence in humpbacked people and an excitable nature, even inclined to malevolence. Both are to be explained by the same cause. Those who are excluded in their youth by their sufferings from the play of their equals in age become reserved, and find in books a compensation for the lively games of youth. Thus they develop a higher intelligence, which causes them to surpass their contemporaries in this respect. The mental capacity is thus increased while the body becomes crooked, and their intellectual superiority then often induces them to revenge themselves for the derision which their deformity has drawn upon them.

From antiquity, large genital organs and an increased sexual instinct have been ascribed to humpbacks. Hence the

fable that the well-developed Priapus was driven away by the men of Lampsacus because his sexual instinct brought about a scarcity of the women in that place. This observation is not without foundation. I have had opportunities of observing, not only in the living but also on the dead body, that humpbacked men have, in fact, the penis very large, and this is explained by the obstruction to the return of venous blood ; on the other hand, I have personally no knowledge as to whether their sexual instinct is increased.

The result of all these disturbances is that severely skoliotic people rarely attain old age. Although some exceptions occur, nevertheless the dictum of Hippocrates in the book Περὶ Ἄρθρων is thoroughly justified. 'It has happened that some people have carried their humpback without inconvenience and without disease even to old age ; nevertheless few have exceeded sixty years, and the greater number have not reached it.'

Treatment of Skoliosis.—With regard to the treatment of any disease, the first question is whether a spontaneous cure is possible or not, and with what probability it may be expected. For skoliosis this question must almost always be answered in the negative. Slight single curves may possibly disappear by means of the muscular activity of the patient himself, but if double curvature is present, indicating that bony changes have set in, then all hope of spontaneous cure must be given up. Any retrogression of the curvature which may be produced will be entirely due to the treatment adopted.

The treatment which is necessary varies according to the degree of the skoliosis.

In the first degree (slight deviation) it may be possible to strengthen the vertebral column and to keep off injurious effects. The foundation of the strengthening treatment is a good, well-arranged diet, with a healthy residence and regular exercise in the open air. The clothing should be light and loose, so that it may offer no hindrance to free movement of the body. In disposition to chlorosis, iron and quinine are the most effective medicines. If symptoms of scrofula are present—which, however, rarely happens at the commencement of skoliosis—cod-liver oil should be given ; mud baths also may be used ;

cold frictions and cold river and salt-water baths are also refreshing and strengthening; swimming is a very desirable addition, as it is a form of movement which involves no weighting of the vertebral column. Systematic massages of the muscles of the back may possibly have some good effect, but must be limited to slight rubbings and kneadings applied equally to the two sides, as there is too little support for unsymmetrical massage, and therefore the latter would be rather detrimental than otherwise. Rubbing the back with arnica, spirits of camphor, or what has been from ancient times especially recommended for this purpose, viz. spirits of formica, may act favourably, though certainly we must not expect too much from them. Slight exercises and marching, especially the slow, military step, when the children are sufficiently developed and possess the necessary balance for them, assure a better carriage and firmer gait. Any over-exertion of the body by muscular movement is, on the other hand, to be carefully avoided, and all exercises must be so ordered that both sides of the body are equally used. One-sided muscular exercises should only be used by those persons who are able to understand thoroughly the complicated muscular mechanism of the human body, and that is much more difficult than most physicians think. In no case should we permit gymnastic attendants of either sex on their own private judgment to carry out one-sided movements, as certainly in such cases harm would be done.[1] For repose a firmly padded horsehair mattress upon a perfectly horizontal couch should be used, with slight raising of the head by means of a cushion stuffed with feathers or, by preference, horsehair. The back is thus supported in the best position without the risk of its assuming a bad posture as it does on a soft bed, by the sinking down of the latter during a long night's rest. It is advisable also during the day to lay the child when fatigued upon this couch. Mattresses prepared with aromatic herbs, as used to be recommended, are simply absurd. A still harder support, such as the favourite way of laying the child down on a carpeted floor, is not advisable, as it is

[1] In ordering one-sided exercises, I have found it necessary to test the effect and find out myself the exact movement which the individual requires to bring about the desired result. Different individuals use their muscles so very differently.—N. S.

more fatiguing than strengthening. If children have a great inclination to curl themselves up while asleep, it is well to fix them in bed. This is best done by the so-called padded plate. A four-cornered plate of iron bears on its upper surface a strong horsehair padding and three soft leather straps, of which one is to go round the pelvis, and the other two round the shoulders. The plate is simply laid in the bed and keeps in its place by its own weight. All three straps are now fastened quite loosely so that they do not press in any way. This will prevent the body from being turned on one side. The horizontal position on the back thus enforced is very well borne by children, who soon sleep as well in their apparatus as if they were lying freely in bed.[1] In all positions and movements care must be taken that one shoulder does not become prominent. Especially in writing is it necessary that the child should sit at a large table with straight (not round) edges, the chair so placed that the edge of the table is exactly above the front edge of the seat, the height of the seat such that the elbow can rest on the table in a natural position; the copy-book must lie straight on the table, and not be turned obliquely; both elbows must rest upon the table; and the head must not be inclined to one side. The seat should have a tolerably high back, slightly inclined backwards, so that the child when fatigued can rest his back against it; the two ischial tuberosities should rest firmly upon the middle of the seat, and not upon a corner or edge. If attention be paid to all these recommendations then firm and broad chairs and tables are far better than any special desks, which are generally undesirable because of the small size both of the seat and desk. In sewing and pianoforte playing, &c. a symmetrical position may be adopted without prejudice to these occupations. This is, however, impossible in violin playing, as here both sides of the body are so very differently occupied. We shall therefore do well not to allow children to practise the violin who are suspected of a tendency to skoliosis, unless their circumstances require it so imperatively that the risk of deformity must be incurred. All one-sided weighting

[1] The same effect can be produced by means of a light apparatus, which permits the child to move easily, but which prevents him curling up in bed, as described by me in *Curvatures of the Spine* (Renshaw, 1884).—N. S.

must be avoided as far as possible. For girls especially, carrying school satchels, which are often heavy, comes under this interdict. For quite young girls the plan has been lately introduced of carrying the satchel upon the back, by which plan no injury can be incurred, and it is therefore strongly to be advised in all cases where there is any suspicion of a tendency to skoliosis. When girls have passed their tenth year they will not generally consent to carry the satchel on the back, and then it is most advisable that they should frequently change their hands, so that each hand should carry the satchel for an equal time. In no case should half-grown girls of from fourteen to fifteen years old carry little children upon their arms, as thus the back is in the highest degree disposed to lateral curving; nor, unless the social circumstances imperatively demand it, should they be allowed to carry any other heavy weights on one side. The common expression 'the child has over-lifted himself' or 'grown out' may well have an anatomical justification, inasmuch as ligaments or muscles may be strained from this cause, and thus an impetus is given to a lateral deviation of the vertebral column.

As to lumbar skoliosis, it is first necessary to establish by precise measurement whether both halves of the pelvis are on the same level. If this is not the case, we must restore equality by the insertion of a cork sole into the shoe on the lower side. This treatment has been objected to as insufficient, the children being able to correct the difference by standing with one knee bent. This is true, and therefore it is precisely for this reason that the greatest care must be taken that no such habitual position should develop; but the children should be made to stand with both knees straight. It is especially important, even when both halves of the pelvis are symmetrical, that a bending of one knee-joint, especially the left, should not be established as a habit. As soon as one knee-joint bends, the affected half of the pelvis sinks, the opposite gluteal region protrudes very much (the 'se hancher' of the French), and the vertebral column is compelled in order to keep an upright position of the body upon this inclined base to curve in the lumbar region towards the depressed side. We should therefore most energetically insist that girls should

accustom themselves to stand with both legs straight and when tired to sit down. All standing long enough to cause fatigue is therefore to be avoided as much as possible, because it induces one-sided pelvic sinking, owing to bending of the knee. If the back is very weak, as for example with girls who have grown tall very fast, and have weak muscles, then it may become necessary even in this stage to give them artificial support by means of a corset. The corset extends over the crests of the ilia almost down to the trochanter in order to obtain a firm basis on the pelvis, and mounts up to the axillæ, and may even be brought as far up on the back as the upper edge of the shoulder-blades. From the posterior upper border broad bands pass on each side of the middle line, which surround the shoulders, and then are brought backwards to be fastened by hooks or buttons. In front and behind two strips of '*blanchets*' are placed on both sides of the middle line, which are closed in front with the well-known mechanism, and behind are laced together. The lateral portions of the corset have some whalebones for support.

In severe cases which approach the second grade of the deformity a greater amount of firmness may be afforded by sewing in a larger number of '*blanchets*' into the corset, and if necessary a pressure may be exercised against the curves by bending them. The corset acquires still greater solidity when it is closed behind and laced in front. The lower edge on the back part is formed by a well-padded pelvic girdle made of iron, which surrounds the posterior half of the pelvis as far as the anterior superior iliac spine on each side, and is closed in front by a band and buckle. The lighter the corset the more comfortable it is; yet we must not carry the preference for a light corset so far as to choose one which is insufficient to supply a firm support to the back.

For cases of the second grade, which are characterised by a distinct double curve, all the directions above given are applicable, with the addition of means which are calculated to redress the curvatures. Amongst these means may be classed gymnastics specially devised for this object, and indeed this is of such importance that Delpech[1] rightly said that without gymnastics he would have to renounce orthopædics.

[1] *Orthomorphie*, ii. p. 179.

This gymnastic system has, on the one hand, the aim of strengthening the whole constitution, the muscles, the bones, and the joints, and of regulating digestion, and even menstruation; in this respect it does not differ from common gymnastics. On the other hand its aim is to select special positions and movements of the body, by which the curvatures are lessened as far as possible, and indeed eventually removed. Since the patients are unable to carry out these movements by their own strength, every exercise should take place under the guidance

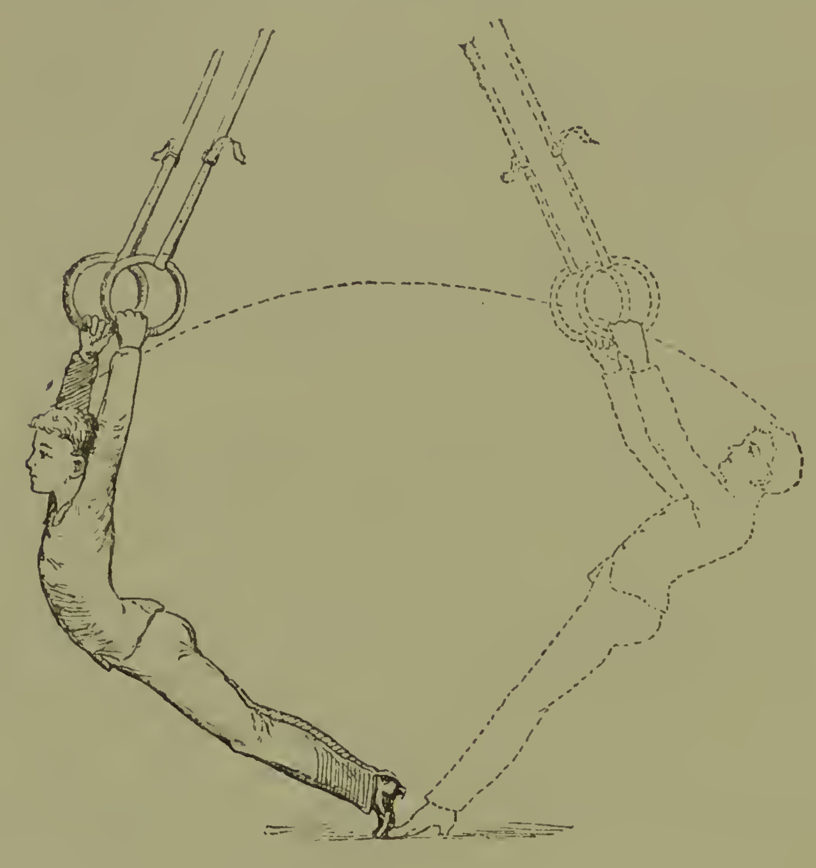


Fig. 5.

and with the help of a trained teacher. Only in this way can be attained the precision especially necessary for these cases. We are not referring here to one-sided muscular exercises, as in the Swedish gymnastic system—that is, taking into consideration and trying to strengthen those muscles exclusively which are supposed to be weaker than their antagonists—but of opposing, by opposite curving, the fixation of the original curvature by shortening of the muscles and ligaments, and of favourably acting upon the bones by reversal of the abnormal pressure

relations, and thereby preserving the mobility of the spinal column, which so easily suffers serious damage from exclusive treatment by means of mechanical apparatus. Further, we should assist the mechanical apparatus by the action of the hands, as the former is intended to assist the latter, and when possible to preserve and advance the improvement which we have commenced by that most perfect instrument, the human hand.

The following are the simple exercises which are to be recommended:—

(*a*) *Exercises while Standing and Sitting.*—1. The patient sits upon a low, slightly padded bench; the gymnastic instructor behind places his knee between the patient's shoulder-

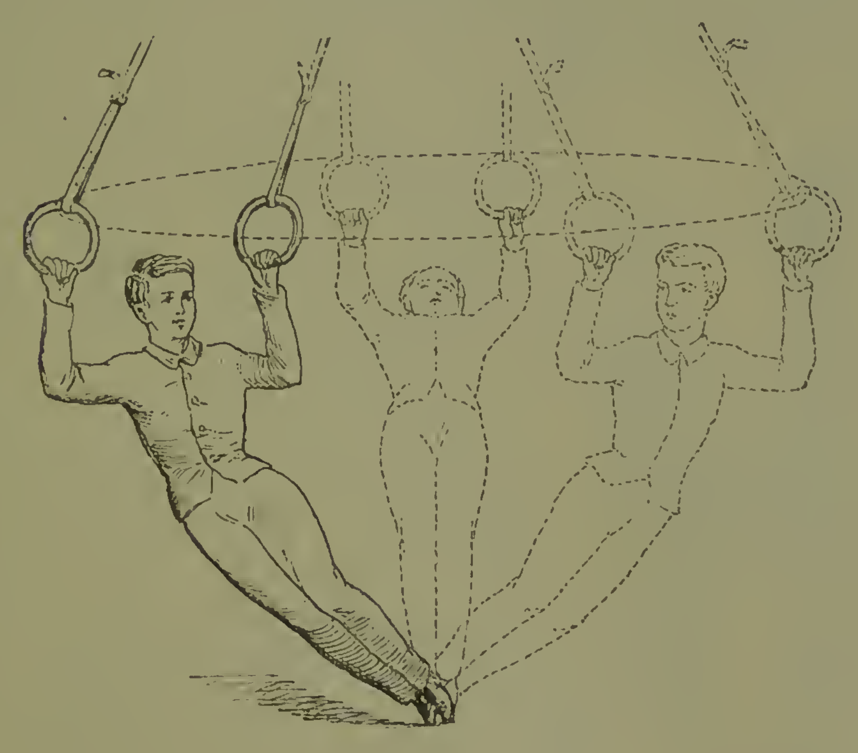


FIG. 6.

blades, the patient's body being straight and his hands firmly supported upon his hips. Rotation in the lumbar portion of the vertebral column right and left, the pelvis being fixed, and the gymnast helping at the shoulders.

Preservation of the normal rotation movement of the lumbar region. If left curvature of this region be present with corresponding rotation of the vertebral bodies, we may carry

out the rotation to the right somewhat further than to the left.

2. The patient seizes two large rings, fastened by long straps, with both hands, the lower ends of the former being level with his shoulders.

His feet remaining on the same spot, he bends himself so far forwards that his arms are stretched quite straight, whilst the whole body forms an arch convex forwards. He then moves (when necessary, with assistance) into and beyond the upright position until he leans backwards, his arms being extended. He then leans forwards again, and so on three times (see fig. 5).

3. Circling with the rings (fig. 6). The hands grasp the rings at the same level as before mentioned. Forward bending until the arms are straight. Right or left circling from this position, either with arms extended or with gradual flexion, by which the circles become smaller.

Object of these exercises: To counteract the fixation of any particular curve by means of thorough exercise of the column.

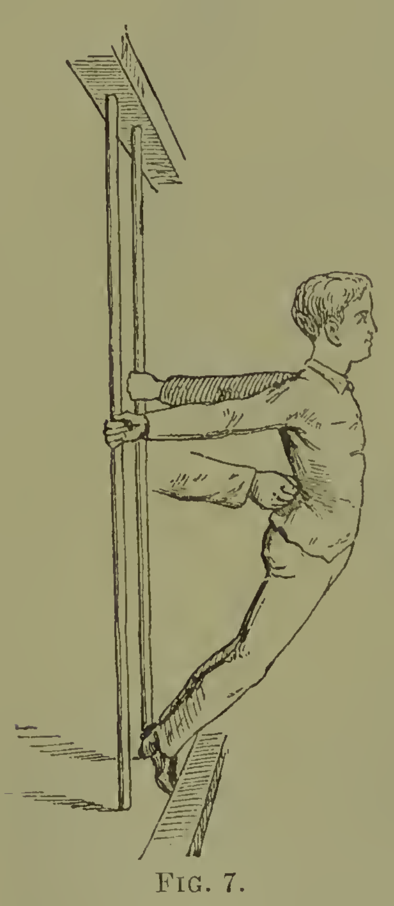


FIG. 7.

4. Forward bending between two vertical bars. Two vertically placed and removable bars are so fixed as to correspond with the width of the shoulders. The patient grasps these bars with both hands, somewhat below the level of his shoulders, and bends forward, while raising himself upon the points of his toes until the arms are straight and his body forms a uniform arc convex forwards. If this curve is not easily produced, the assistant must help by means of pressure upon the sacrum. Rising from this to the original position, whilst the assistant opposes a slight uniform resistance by pressure upon the sacrum. To be repeated three times (see fig. 7).

(*b*) *Suspension Exercises.*—5. The patient hangs upon a horizontal bar, which is high enough to prevent his feet touching the ground. The assistant standing behind him places both hands upon the waist of the patient. The patient draws himself up by the hands until his chin projects over the bar whilst the assistant gives just so much help that the exercise shall not be too severe. The patient then slowly and gently lowers himself, then rests suspended, and repeats the exercise three times. Object: Extension of the body by its own weight, powerful exercise of the muscles of the shoulders whilst pulling up.

6. 'Upward swinging' at the back of an obliquely placed ladder (fig. 8). The patient grasps from behind, with both hands, the sides of a tolerably wide ladder, placed obliquely at an angle of 45°, so that only the tips of his toes touch the ground. Now he swings his body right and left from the lumbar region downwards by contraction of the sacro-lumbales muscles. When swinging to the right his right hand grasps the side of the ladder somewhat higher, and when swinging to the left, the left hand is placed the higher. Thus the body mounts gradually in regular gradation at the back of the ladder. Arrived at the top the descent commences in reverse manner, without assistance. Object: Especially to counteract lumbar skoliosis. The weight of the body stretches the lumbar region, whilst the muscles on both sides of it are equally exercised by the right and left swinging, and thus the fixation of any special curve is counteracted.



FIG. 8.

7. Support and suspension in the stretching frame. From the position of the support, the patient by relaxing the tension in the hips and arms slowly and equably lowers his body into

the position of suspension. After a pause he again raises himself into the position of support by the help of the assistant. To be repeated three times (fig. 9).

8. Backward hanging upon an obliquely placed beam provided with crossbars at the sides. The patient hangs with his back against the inclined beam whilst his raised arms grasp the crossbars, and thus prevent him from gliding down.

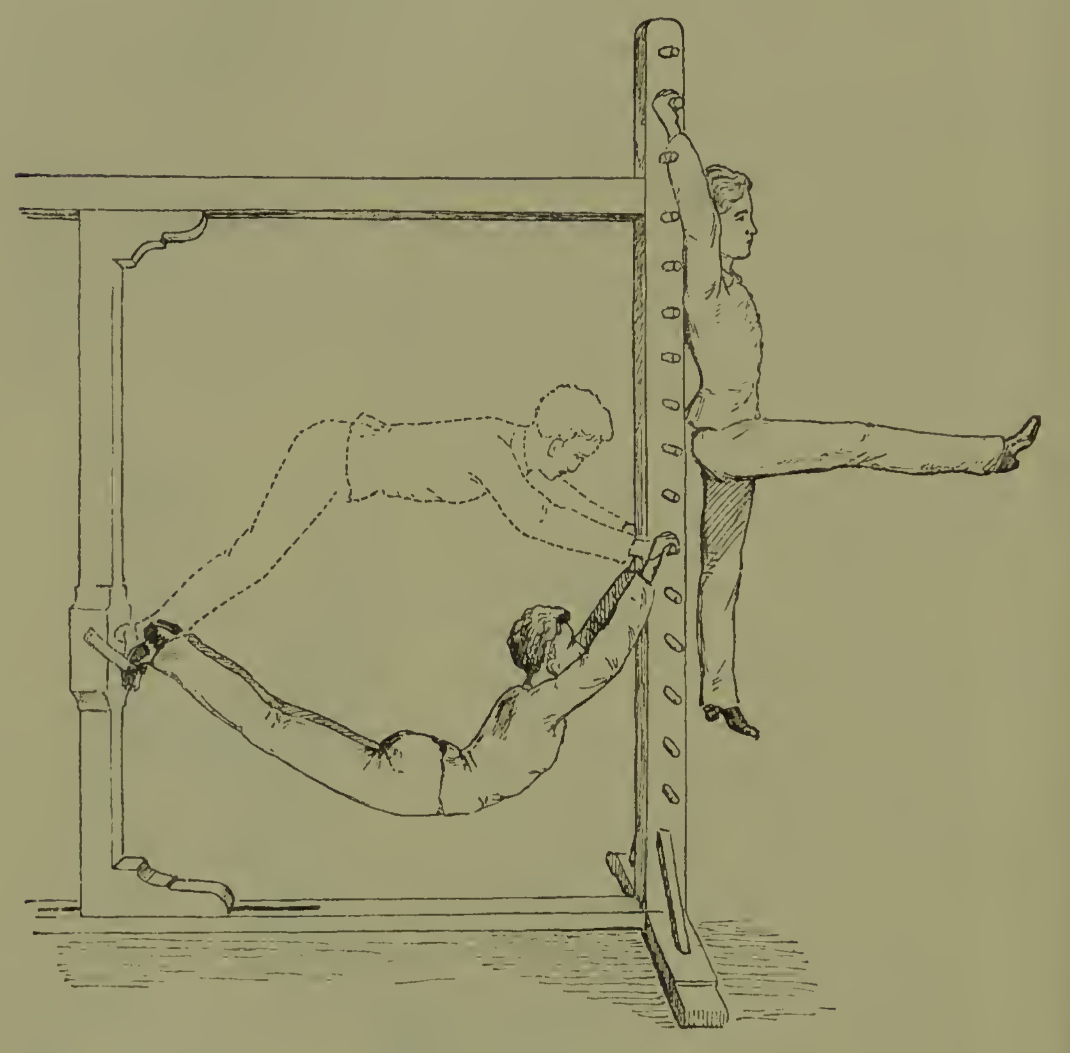


Fig. 9.

After some time he raises himself by pressure of the feet upon a crossbar. He then pauses and repeats the exercise three times.

9. Hanging upon a beam with crossbars and 'leg-raising.' The patient hangs in the manner represented in fig. 9. The right leg, the knee being extended, is raised three times to a right angle with the body, then the left leg, and finally both

legs are raised together, when necessary, with assistance. Whilst the weight of the body stretches the vertebral column, the muscles passing down from the lumbar region and the pelvis to the thigh are vigorously exercised.

10. Raising from the freely horizontal position. The patient lies upon a slightly padded table (the so-called divan), with the upper part of his body swinging freely over the edge of the table, whilst another person of about the same weight sits upon his legs and keeps him in position. Downward bending at the hip-joint to right angles, upraising from the bent position and backward bending of the body till the trunk forms an arch convex forwards. Increase of the back curve by hand pressure of the assistant against the shoulders. Three times repeated. Object: Powerful exercise of all the muscles of the back (fig. 10).

11. Backward bending over a bar (the Wolm) (fig. 11). The patient supports himself by the middle of the sacrum upon the padded strong crossbar of a small framework. Whilst

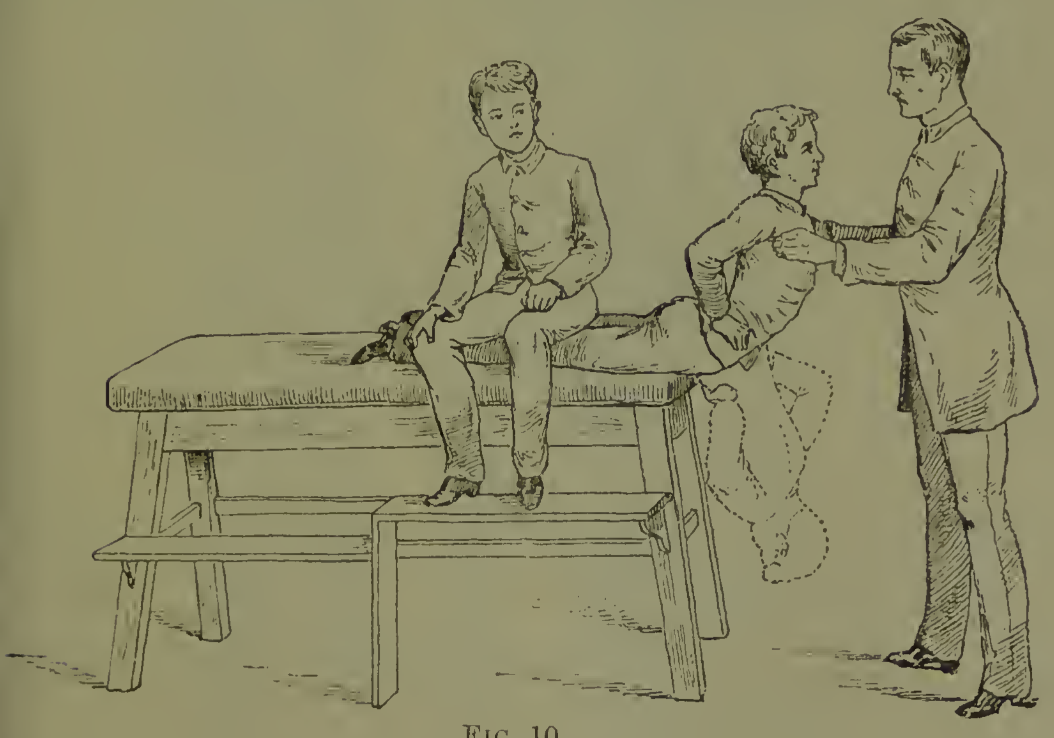


Fig. 10.

the gymnast stands behind the patient, and prevents him from falling backwards by the support of his hands, the patient gently lowers himself into a well-flexed backward position. The padded crosspiece must exactly support the centre of gravity

of the body, so that the upper and lower halves of the body accurately balance; with slight exercise of the dorsal muscles a well-flexed backward position is attained.

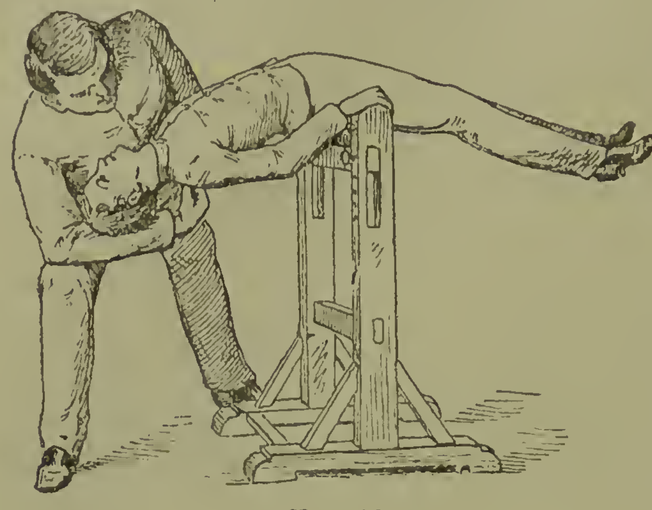


Fig. 11.

For the exercises 4, 7, 10, 11, and partly also for 2 and 3 the following remarks must be made: The row of vertebral bodies forms, as has been thoroughly explained above, in every skoliosis a much greater deviation than the row of spinous processes. If a patient in whom the row of the spinous process forms the concavity, and the row of the bodies the con-

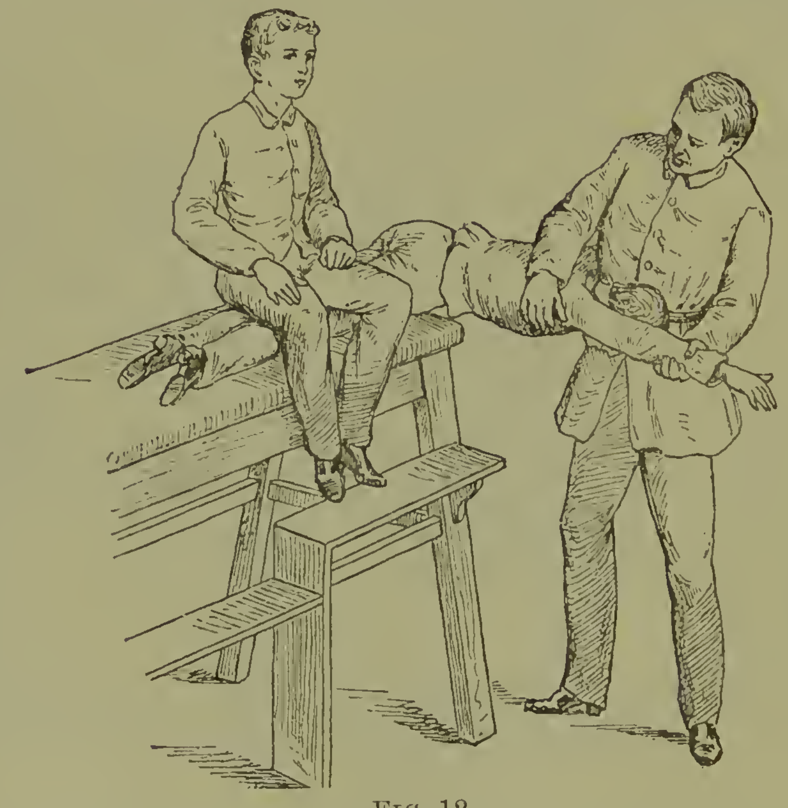


Fig. 12.

vexity of a considerable double curve, is placed in such a position that the whole weight of the body acts in the direction of extension, then the row of the bodies must approximate the

middle line from both curves, *i.e.* the bodies must rotate back again and from both curves simultaneously towards the middle line. This is the reason why I recommend the extreme backward bent position of the trunk both in standing and especially in suspension. I believe we thus attain a position in which, besides the removal of the curve by the weight, a rotation back again of the vertebræ also results.

Exercises upon the parallel bars are not to be recommended for orthopædic purposes, as here the extension of the vertebral column by the weight of the body is less than in suspension,

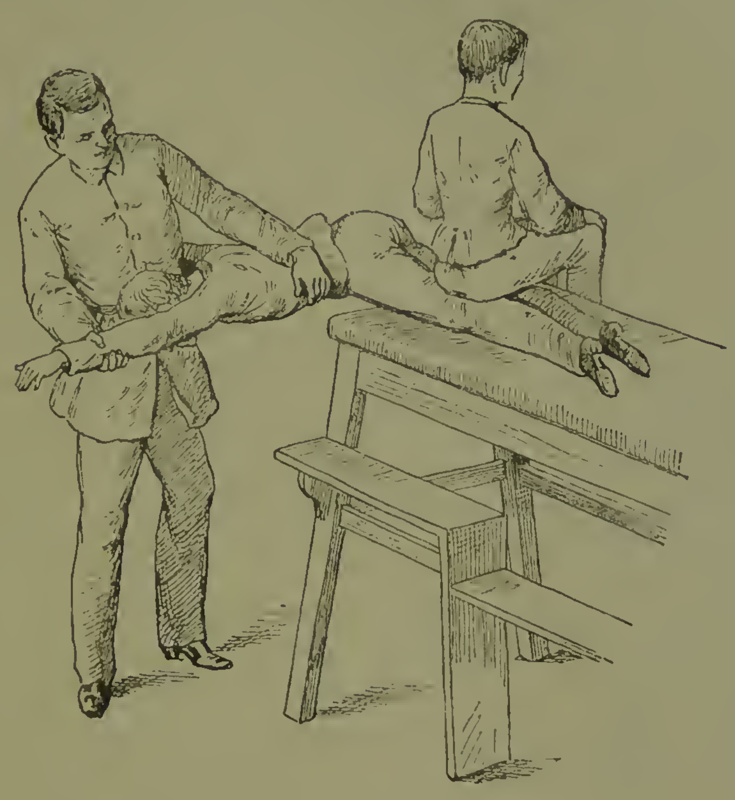


FIG. 13.

and the strain upon the shoulders is decidedly a disturbing element. On the other hand, swinging in suspension from rings or from the trapeze, with the arms either extended or well flexed at the elbows, is to be recommended.

As examples of exercises which aim at reducing the curvatures by direct pressure the following may serve :—

1. The patient hangs at the back of an inclined ladder. The assistant stands behind him and whilst firmly supporting the left half of the pelvis with the knee, and the left axilla with the left hand, he presses with the right hand with all

his strength against the projecting ribs, to which pressure the patient, by relaxing his trunk muscles, makes no resistance.

2. The patient places himself in 'a freely swinging horizontal position' of the upper half of his body, as in exercise 10, at the level of the assistant's waist. The latter buckles a firm leather girdle round his body, which has at its back a movable loop (fig. 12).

The assistant then places himself at the left side of the patient's head, and the latter seizes the loop of the girdle with his left hand. The patient's fully extended right arm is firmly grasped above the wrist by the left hand of the assistant, who also places his right hand over the patient's back against the protruding ribs of the dorsal curve. Whilst the assistant applies firm pressure with this hand against the ribs, he bends the patient's back to the right, and thus presses the curve in the reverse direction. For this exercise the assistant has very considerable power, as he brings his own weight to bear upon the patient: and if he is at all strong, he is able to correct even severe curves in the back. It is even necessary for him to be cautious that he does not injure the vertebral column by too great an exercise of his strength.



Fig. 14.

3. The patient is in the same position as before; the assistant stands at the right side of the head; the patient grasps the loop of the belt with his right hand and stretches out his left arm by the side of his head (fig. 13).

The assistant grasps this arm close above the wrist with his own right hand and applies his left hand to the lumbar curve. Then follows bending of the body to the left, whilst the left hand of the assistant exercises a counter-pressure against the lumbar vertebræ. This exercise also leads directly to reversal

of the curve, and it is not so difficult in the lumbar region, because there is no resistance of the ribs to be overcome.

4. 'Right-sided and backward bending' with a Seeger's bar-bell. The patient grasps a bar-bell, and raises it with his arms vertically above his head. The assistant stands behind the patient, grasps him by both elbows, and whilst he depresses the arms somewhat backwards, and at the same time to the right, forces the back to lose its right-sided dorsal curve. The assistant in this exercise, using the arms as levers, presses by means of the right shoulder-blade the right extended serratus magnus muscle against the projecting ribs, and by the transference of the pressure by means of the ribs to the vertebral column compels the latter to return towards the middle line, or eventually even to pass beyond it.

A similar correction of the curve, however, may be effected by the patient himself with much less strength if he supports the outstretched right arm against a somewhat lower firm object, and then endeavours to bend his back convexly to the left. The same object is aimed at by the exercise when the patient rests the palm of the right hand against the projecting ribs of the right side, while his elbow is well bent, and endeavours to give to the back, supported by this counter-pressure, a curvature to the left.

In a similar manner the patient may also himself attempt the correction of the lumbar curve, but he never succeeds in removing both curves by his own strength—a result, however, which is quite possible with the aid of the assistant. Balancing exercises increase the elasticity and suppleness of the body, but have no direct effect upon the curves.

The second method of treatment of skoliosis is the operative.—Here the question is whether one is able to improve the position of the vertebral column by means of subcutaneous section of muscles or their tendons. In order to answer this question it is necessary to take a short retrospective glance at the history of tenotomy.

After some feeble attempts by Thilenius (1789), Sartorius (1806), C. F. Michaelis (1810), and Delpech (1816) to facilitate the correction of deformities by means of section of tendons with open wound, Stromeyer introduced subcutaneous teno-

tomy, and first published his experiences regarding the operation in 'Rust's Magazine,' Bd. xxxix. and xlii. in the years 1833 and 1834.

The new procedure was, however, at first rather coldly received, until by a peculiar conjunction of circumstances it was suddenly accepted in surgery with more brilliancy than has attended the introduction of almost any other operation. A young Englishman of the name of Little (later on the well-known orthopædic surgeon) suffered from talipes equinus of one foot with a slight degree of varus, in consequence of infantile paralysis. He consulted the authorities in his own country, but all were opposed to section of the tendo Achillis, as they considered this a dangerous operation, and uncertain in its results. Little went over to Germany and sought Dieffenbach's advice. Dieffenbach declined to undertake the operation, as he had never performed it, but advised Little to go to Dr. Stromeyer, in Hanover, who had more experience in the matter.

Little followed the advice, had his tendo Achillis divided by Stromeyer on June 6, 1836, and after some weeks returned to Dieffenbach treading upon the entire sole of the foot.

By means of Dieffenbach's powerful support, subcutaneous tenotomy received an enormous impetus. In all civilised countries it became the favourite operation of the day, and all the world was surprised to find how free the operation was from danger, and how rapidly subcutaneous section of even large muscles and tendons was recovered from and how very much the correction of many deformities was facilitated by this means. There was no longer any disfigurement or deformity, it was thought, which might not be quickly mastered by the aid of subcutaneous tenotomy.

The same enthusiasm prevailed in France, where orthopædic surgery then stood in the foreground of surgical interest, and where, therefore, subcutaneous tenotomy met with a very favourable reception. The surgeon who was the most eager in taking it up was Jules Guérin, the director of a large orthopædic institution in the neighbourhood of Paris, the luxurious arrangements of which had excited Dieffenbach's astonishment.

It was natural that so simple and safe an operation, which had been attended with such brilliant results in club-foot and

wry-neck, should be tried, also, for the most common of all deformities, viz. skoliosis; and J. Guérin adopted this operation with characteristic energy.

He deposited, on May 6, 1838, with the Académie des Sciences a sealed letter, in which he secured for himself the priority of this operation, named by him 'Myotomie Rhachidienne,' and then he tenotomised with energy. As, however, in skoliosis it was not so easy to discover which muscles were the shortened ones, he sought them with the knife; and it once happened that he cut subcutaneously, on one patient, muscles and tendons in twenty different places. He asserted that he had attained brilliant results, even in cases of the third grade of the deformity, and praised this method as the best and most rapid of all those hitherto employed for the treatment of skoliosis. But notwithstanding the great success which he claimed, he failed to demonstrate his cures, or to convince other surgeons of his success; on the contrary, a rumour spread in Paris that several skoliotic girls, whom Guérin had treated by tenotomy, had not only not been improved, but even rendered worse from the dorsal muscles having been made weaker, and Malgaigne undertook the very troublesome and unpleasant labour of elucidating the facts. As Guérin, on being interrogated by letter, refused to bring forward the patients whom he stated to be really improved, or even cured by the operation, Malgaigne obtained the names of the patients operated upon by Guérin in the Hôpital des Enfants, and visited them at their own homes in order to discover their condition by personal examination. Upon the ground of these investigations, Malgaigne wrote a 'Mémoire sur la valeur réelle de l'orthopédie et spécialement de la myotomie rhachidienne dans le traitement des déviations latérales de l'épine,' in which he asserted that not one of the patients whom he saw had been cured, but the greater number of them were in a very deformed condition. This Mémoire was laid by Malgaigne before the Académie de Médecine, and excited a storm of indignation against Guérin and his followers. To form a judgment upon the Mémoire, the Académie chose a Commission consisting of Velpeau, Baudeloque, and Roux, who undertook the investigation of the actual facts, and at the sitting of November 5, 1844, presented their report,

which amounted to this, that the Commission confirmed Malgaigne's statements in every particular; Guérin, who was wounded in his most sensitive point, defended himself with a wonderful diatribe, but was obliged to give way before the very powerful onslaught of Velpeau, and in the sitting of November 19, 1844, the Académie passed a vote of thanks to Malgaigne for his services, and entered it in its 'Transactions.'

Thus was *Myotomie rhachidienne* annihilated, and it has never since recovered from the blow, at least as a generally available method of treatment of skoliosis.

It is somewhat different when in special cases, in consequence of wounds or suppuration, a cicatricial band has been formed in the deeper tissues, which curves the vertebral column sideways. In such a case subcutaneous section of the cicatricial band is a thoroughly justifiable operation, and Volkmann[1] by performing it upon a boy, who in consequence of cicatricial contraction of one sacro-lumbalis muscle was affected by a severe lumbar skoliosis, obtained by this operation, with subsequent orthopædic treatment, a rapid and brilliant cure.

The third method of treatment of skoliosis is the Antistatic, as I call it. This method consists in obtaining an improvement of the skoliosis by an intentional obliquity of the pelvis. As has been stated above, this method can only be taken into consideration when the lumbar curve is the more prominent. When the dorsal curve predominates, this plan is ineffective; we may even say that it does harm. I have already, in the treatment of the first grade of skoliosis, pointed out how important it is to recognise actual shortening of one leg, and to compensate it by an addition in the shoe, for only thus can the position of the pelvis be rectified.

In the treatment of the second grade of skoliosis we proceed thus:—we intentionally place the pelvis in an oblique position, in such a way that the raised side corresponds to the convexity of the lumbar curve, in order thus to cause the retrogression of the latter. As has been stated in detail above, the lumbar curve directs its convexity with rare exceptions to the left, therefore the oblique position of the pelvis must be obtained by raising its left side. We can attain this object in

[1] Volkmann, *Beiträge zur Chirurgie*, 1875.

two ways, namely, by an addition to the shoe or by the use of an oblique seat. The addition to the shoe is extremely simple. Every shoemaker possesses ordinary wedge-shaped pieces of cork, which many ladies wear in order to appear somewhat taller than they naturally are, and by a higher arch to the instep to cause the foot to look 'coquettish,' as a shoemaker once said to me. These cork wedges have their bases at the heel and their thin edges in the middle of the sole. Such wedges are of different sizes, of from $\frac{1}{2}$ to $2\frac{1}{2}$ inches thick at the heel; they are simply placed or glued on to the back part of the shoe, and by raising the heel into a slight equinus position of the foot, add the thickness of their base to the length of the affected leg, unless indeed, the patients negative the effect by bending the knee, against doing which they must be cautioned. Many girls afflicted with skoliosis feel themselves essentially benefited by the addition (even when they have no real shortening), and are afterwards not able to walk without one, a certain proof that they do not negative the effect by bending the knee joint. The thickness of the addition which is necessary varies between 1 and $2\frac{1}{2}$ inches. At least I have not exceeded this, and I have had no occasion to desire any increase, for the raising one side of the pelvis $2\frac{1}{2}$ inches is quite evident when the body is naked, and a further increase of the elevation would be unpleasantly observable when the patient was dressed. Thus, with this addition, the left half of the pelvis is raised during walking, but not when the patient is sitting, and in consequence the lumbar vertebral column alternates between the somewhat corrected position while walking, into its former lateral curve while sitting.



Fig. 15.

Now in order to preserve the elevation of the left side of the pelvis while sitting, a seat has been invented, one side of which is raised. This 'oblique seat' was known to Bouvier, and has quite recently been used, especially by Volkmann and Barwell.

I must admit that I am not much in favour of it. Wherever a person may go he may easily take with him an addition to his shoe, but it is impossible that he can either take about with him or meet with an oblique seat. We must therefore give up the idea of the oblique seat as an effective persistent agent, because we cannot prevent the patient from often sitting upon a horizontal seat. This would be in itself no very great drawback, but even for sitting at home and at school I have not as yet been much pleased with the oblique seat, yet I will not deny that in special cases it may have a favourable effect. The indications for its adoption are as follows:—In the first place, a preponderating curve in the lumbar portion as distinguished from the dorsal curve; in the second place, the experiment of elevation of the left half of the pelvis must exercise a favourable effect upon the position of the lumbar vertebral column; and thirdly, the oblique seat, which is best made of wood or with a padded horsehair cushion, must not raise the left half of the pelvis more than from 3 to 4 inches, for more than this appears to me to be undesirable; and fourthly, the patient must be carefully watched by those around her, to see that the oblique seat really affects the carriage of the body. If all these four conditions are fulfilled, I would without further consideration recommend the use of this seat. In the horizontal posture the position of the pelvis naturally does not come under consideration, as the trunk does not support itself upon the pelvis but rests upon the couch.

The fourth method of treatment of skoliosis is the mechanical. This rests fundamentally upon two principles, viz.: extension and counter-extension at the ends of the curved vertebral column, and pressure against the convexity of the curves.

Both methods, though in a somewhat crude form, had been already described by Hippocrates in his Scamnum, but were forgotten during the middle ages. Extension by vertical suspension was first

introduced by Glisson [1] in 1650, viz. with the *escarpolette Anglaise*, *i.e.* a bandage which surrounds the body of the patient at the head, the arms and the hands, and then by a cord was drawn up over a hook fastened in the ceiling. In the year 1692, Nück [2] introduced the extension collar, which has practically preserved the same form up to the present day. Levacher de la Feutrie [3] introduced the use of extension in an apparatus which could be worn, the so-called Minerva machine, which consisted of a pelvic girdle, from which an iron staff proceeded along the spine, which bore a plate between the shoulders fastened with shoulder straps. From this plate a curved piece of iron passed over the head and ended in a cross-piece, at both ends of which the leather collar was fastened at the desired degree of tension. This apparatus was called the 'collar' in England at the beginning of this century, and was much employed for the treatment of skoliosis; less, however, by scientific physicians than by bone-setters, *i.e.* people who without scientific education adventured upon the treatment of deformities with a rough empiricism. The first extension beds, *i.e.* apparatus in which extension was effected in the horizontal position of the body, were used at the end of the last century by Venel and Erasmus Darwin. Venel, a Swiss physician, who occupied himself exclusively with orthopædics, erected in the little town of Orbe in the canton de Vaud an orthopædic Institution, and published in the year 1788 a small pamphlet—'Déscription de plusieurs nouveaux moyens et mécaniques propres à prévenir, borner et même corriger dans certaines cas les courbures et la torsion de l'épine du dos. Lausanne.'

In this (now very rare) brochure is the first description and illustration of the extension bed. This was described and illustrated anew in 1835 by Mellet,[4] who knew of it through d'Ivernois, a pupil of Venel's. It consisted of the following parts. A head-cap buckled at the forehead and two hooks passing under the armpits, which ended in straps that were fastened at the head of the bed, to effect counter-extension. The extension was made from the pelvis with a leathern belt, from both sides of which straps ran downwards, which were fastened by special leathern bands above the knees and ankles, and then passed at the lower end of the bed to the extension apparatus. With or without acquaintance with this apparatus, Johann Georg Heine [5] introduced into his orthopædic institution in Würzburg an

[1] Glisson, *De Rhachitide*, cap. 35.

[2] Nück, *Operat. et Experiment. Chirurgica*. Lugd. Bat.

[3] Levacher de la Feutrie, *Du Rakitis*, 1772.

[4] Mellet, *Manuel pratique d'orthopédie*. Bruxelles.

[5] As several members of the family Heine have occupied themselves with

extension bed constructed upon the same principle, which he used frequently. A young French merchant, named Milly, obtained admission into this institution for treatment of skoliosis. He warmly interested himself in orthopædic mechanics, carefully examined all the apparatus which he found in Heine's institution, and in the year 1823, brought the extension bed in the form adopted by Heine to Paris. Here this excited an amount of attention which is incomprehensible to us. The cure of skoliosis appeared all at once to have become a perfectly simple affair; and now sprang up a number of orthopædic institutions, in which the extension bed was the principal means of treatment.

Milly himself founded an orthopædic institution in the neighbourhood of Paris, which later on came under the direction of J. Guérin.

Erasmus Darwin, the grandfather of the celebrated Charles Darwin, improved the inclined plane, which he had already used, by adding to its upper end a collar for fixing the patient's head. The body slowly sinking down the inclined plane, effected extension of the vertebral column by its own weight. The result, however, of such extension is that the greatest tension occurs between the occiput and the atlas, and thence gradually decreases from above downwards corresponding to the lessened weight. It was endeavoured to maintain stretching of the spine during the day by corsets, which were either furnished with slips of steel, or with whalebones which were first introduced into France in the time of Catherine de Medicis, about 1580.

As regards the treatment of skoliosis by extension beds, utility must be admitted, but it must also be pointed out that the horizontal position, when continued beyond sleeping time and midday rest, is harmful, and the more so the longer and more continuously it is adopted. To condemn young girls

orthopædic surgery and are frequently confused together, I append the following personal notices, for which I am indebted to the kindness of Dr. Riedinger of Würzburg. (1) Johann Georg Heine, the founder and principal of the first orthopædic institution in Würzburg, died in 1830. He was first an instrument-maker under C. K. v. Siebold, the first surgeon in Würzburg. (2) Bernhard Heine, inventor of the osteotome and Extraordinary Professor of Physiology, nephew and successor of the former in the Institute. (3) Jacob Heine, nephew of J. G. Heine (Bernhard's and Jacob's fathers were brothers), Director of the Orthopædic Institution in Cannstadt, author of the work *Ueber Spinale Kinderparalyse.* (4) Carl Heine, son of Jacob, Professor of Surgery in 1872 in Innsbruck, later on in Prague, was ennobled in Austria, and died in the year 1878, of diphtheria.

during the period of their development to keep the horizontal position uninterruptedly for a couple of years, as, according to John Shaw's testimony,[1] was the ordinary treatment during the first twenty years of this century, even in the lighter cases of skoliosis, was in fact to adopt a means which was worse than the disease; for although we succeed indeed in retarding the advance of skoliosis for two years, it is nevertheless to be feared that after this time the bones and muscles, weakened by long rest, will be so much the more inclined to curvature. But, on the other hand, during these two years of recumbency we not only retard but often irreparably injure the bodily and mental development of the patient. These evils are universally acknowledged, and in the present day it is quite out of the question to use the extension bed in so persistent a manner for the treatment of skoliosis. But it is still frequently used during the night and perhaps for two hours' rest in the afternoon.

The extension bed of the present time has practically the same form as was given to it by Venel and Heine. The head is surrounded by a slightly padded collar which is fastened by two leather straps to the head of the bed.

If it is considered necessary to effect some extension also at the shoulders, slightly padded straps are brought under the armpits and fastened also to the head of the bed. The traction on the lower half of the body is effected in all cases by a pelvic girdle, from which long leather straps pass down on the outside of the legs. These may also be fastened in the manner employed by Venel by means of padded leather bands above the knees and ankles. To allow the extension to act only upon the legs without the pelvis participating is always to be avoided, as thus the hip and knee joints are likely to be loosened. We can now render the extension either unalterable —as for example, with a screw—or alterable, so that it yields to any movement of the patient, but is restored again at once. The last kind is by far the most effective, as it allows the patient at least a small degree of movement. An extended steel spring may be used, as in Heine's extension bed, or a weight hanging down freely over a roller.

[1] J. Shaw. On the Nature and Treatment of the Distortions to which the Spine and the Bones of the Chest are subject. Translated into German, 1825.

By using the stretched spring we can only determine the degree of traction by estimating its tension, unless we insert a dynamometer, which certainly insures much greater precision, but which makes the apparatus much more expensive. The freely hanging weight accurately indicates the pull by its amount; yet it has this drawback, that when it is raised by any movement of the patient it causes a sudden strain by falling back into the previous position. In order to avoid this evil the weight has been fitted with rollers upon an inclined plane, by which we rectify the evil, but again make the apparatus more expensive. The amount of power used should depend upon the circumstances of the case. Bouvier gives, as a maximum, 8 to 10 kilos at the head, and 10 to 15 kilos at the pelvis. These are certainly very great weights, but we must remember that a large portion of the power is lost by the friction of the body against the couch.

The *inclined plane* must be provided with an apparatus for diminishing or increasing the inclination, in order in this manner to increase or diminish the extension. The upper fixation takes place either exclusively at the head through the collar, or at the shoulders also; no other appliance need be used, as the body by its own weight effects the extension. This is undoubtedly an advantage which the *inclined plane* possesses over the extension bed; on the other hand, there is the disadvantage, that the degree of the extension gradually decreases from above downwards, and thus is much less in the lumbar portion where it is principally required, than in the neck where it is perfectly superfluous. Both apparatuses, however, suffer in common from the drawback, that in order to obtain any correction of the body worth mentioning, a very considerable extension weight must be used, because only a small portion of the power can be utilised for this correction.

Much more favourable in this respect is the position apparatus effecting a perpendicular pressure against the convexity of the curve, as in this case the curved portion is not *indirectly* attacked from both ends of the vertebral column but *directly* affected by the mechanical action. Nevertheless it must be pointed out, that in reality only one curve is accessible to treatment by pressure, *i.e.* the dorsal curve, in which the

protruding ribs form a favourable point of application for the counteracting apparatus, whilst the lumbar vertebral column, by reason of its position deep in the soft parts, is almost completely withdrawn from direct pressure. Bouvier relates that, when pressure pads first came into use in Paris for the treatment of skoliosis, perforation of the colon with consequent fatal peritonitis in a young girl was caused by lumbar pads. The lateral pressure may be either rigid or elastic.

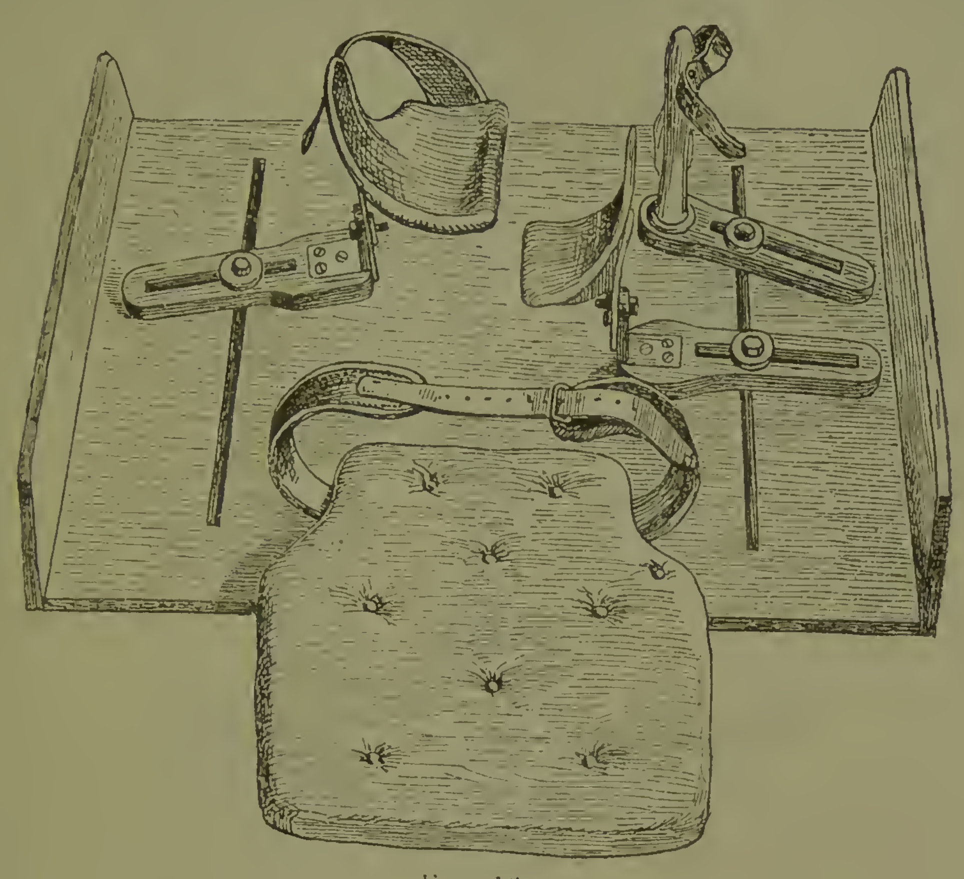


Fig. 16.

Of *the apparatus with rigid plates regulated by screw pressure*, *Bühring's*[1] is by far the best known and most effectual. An iron plate is furnished with a belt for fixing the pelvis and a padded staff covered with leather, which is placed in the left armpit, in order to effect a counter-pressure there. Both pressure plates have crescent-shaped segments and are regulated by screws, the one being applied against the ribs of the protruding side, the other directly against the lumbar vertebræ. Every evening, when the patient goes to bed, the apparatus is

[1] Bühring, *Die seitliche Rückgratskrümmung*. Berlin, 1851.

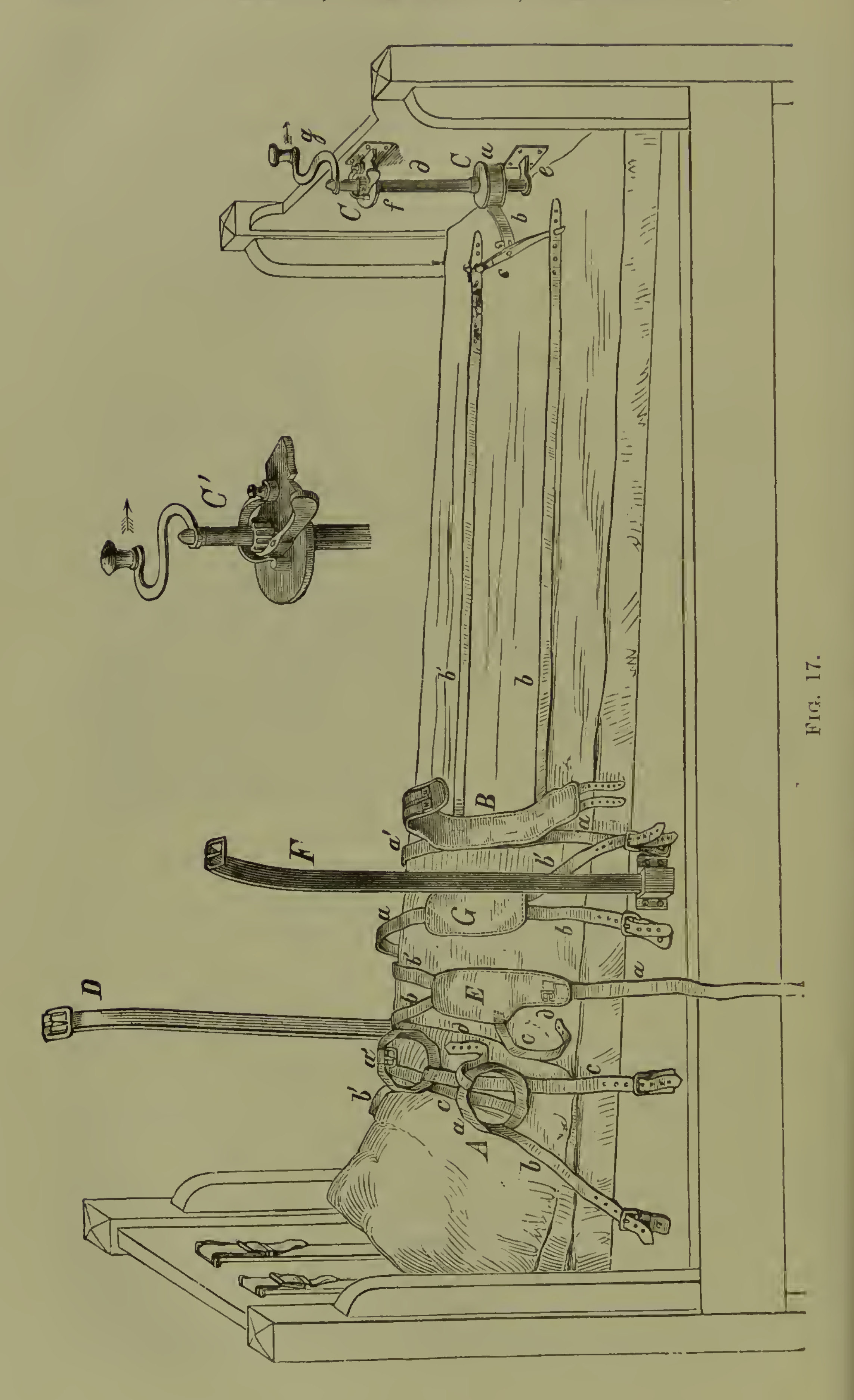


FIG. 17.

rearranged and remains so throughout the night. This fixity is a disadvantage, for apart from the fact that the pressure is a very hard one, the patient may by a slight change of position in sleep negative its whole effect. Notwithstanding this drawback we cannot deny that the apparatus has a favourable effect.

Elastic spring pressure is employed in *Heine-Carus's apparatus*, see fig. 17 (after Schildbach). The patient lies upon a padded iron plate, against which the pelvis and the shoulders are fastened by padded straps. From the plate proceed leathern straps, which carry soft leathern pads, the ends of which are continued into long straps. For ordinary skoliosis, the pad intended for the dorsal curve is fastened to the left border of the plate, that for the lumbar curve to the right border. After the patient has lain down upon the plate and is fixed with the pelvic and shoulder girdles, the leather straps of the pads are fixed by buckles of the requisite tightness to the ends of the long C. springs brought one to each side of the bed.

Very considerable extension may be effected, and yet the pressure, though much increased, is not hard or injurious, as it is effected through the soft leather pads; further the pressure is a permanent one, as by means of the elastic spring it continues even when the patient may have changed his position. By these advantages this apparatus is superior to Bühring's position apparatus.

The third apparatus, acting by lateral pressure, is a simple girdle suspended from a small frame, in which the patient lies upon his projecting side. The idea of this apparatus is tolerably old. Little [1] mentions that he has treated severe skoliosis with this side girdle according to the plans of Lafond, Shaw, and Lonsdale. In later times, Volkmann and Barwell have specially praised this method of treatment. Quite lately, I [2] have myself given to the side girdle, by a slight modification, a more agreeable and convenient form, by which its use is greatly facilitated. A very loosely suspended band of coarse linen, a hand's breadth wide and covered with leather, hangs from two nearly

[1] Little, *Nature and Treatment of the Deformities of the Human Frame*, p. 363. London, 1853.

[2] Busch, *Die Belastungsdeformitäten der Gelenke*. Berlin, 1880.

perpendicular iron rods fastened below to a horizontal board. The apparatus is placed upon a firmly padded mattress which is prevented from sinking in by a wooden bed-frame. The patient

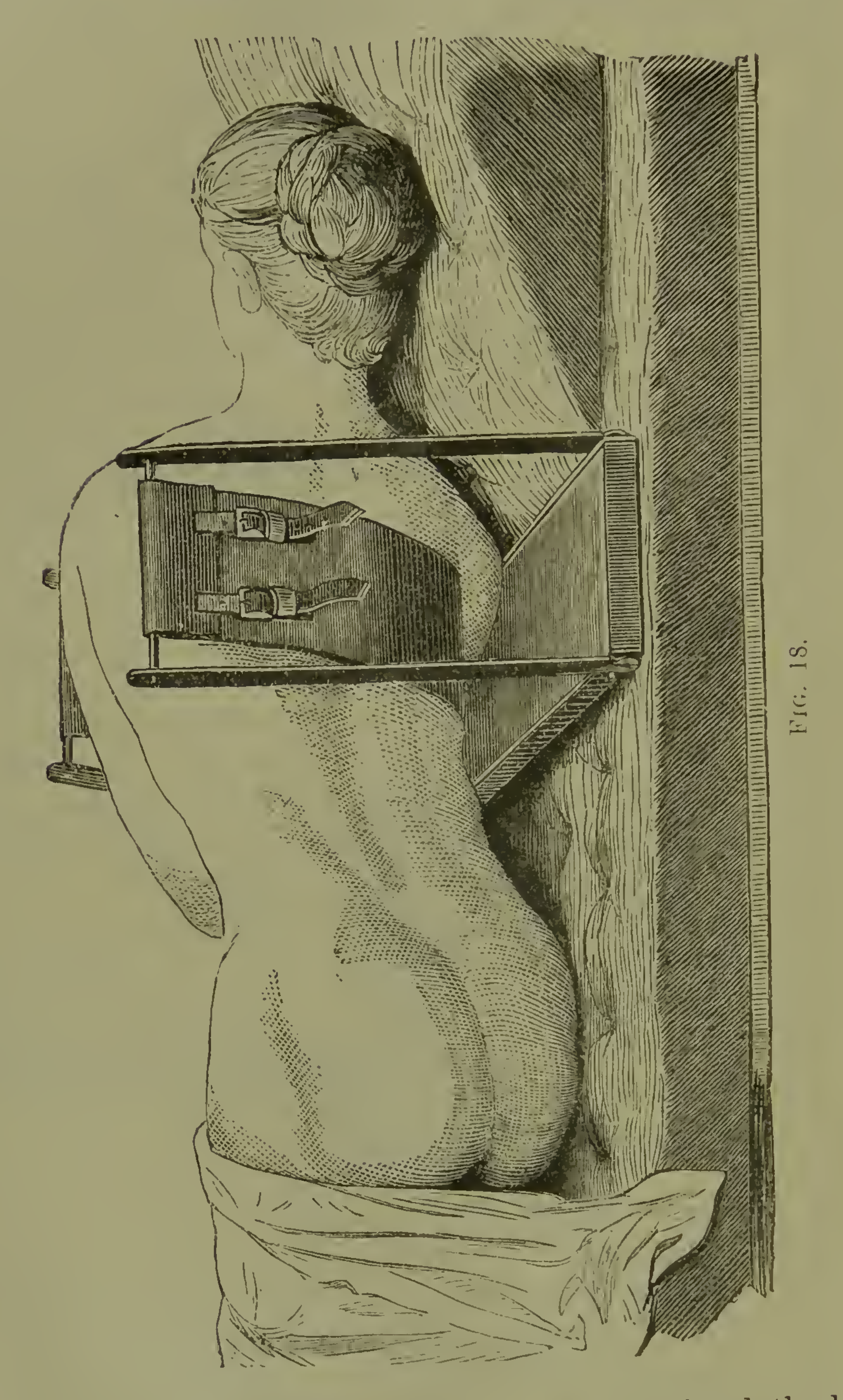


Fig. 18.

lies on his projecting side in the freely swinging band, the lower part of which nearly reaches the board. The head rests upon a

wedge-shaped cushion, the pelvis upon the mattress. Inasmuch as the band bears the weight of the suspended part of the trunk between the head and pelvis, it presses powerfully against the projecting ribs, and by transference of this pressure from the ribs, also presses the deformed vertebral column. The lumbar curve is compensated by the weight of the body. If we give the band the height necessary for the development of its full effect, we see that by its use the curvature is corrected even to the straight direction of the spinous processes, a result which we should hardly have considered possible. Moreover, the

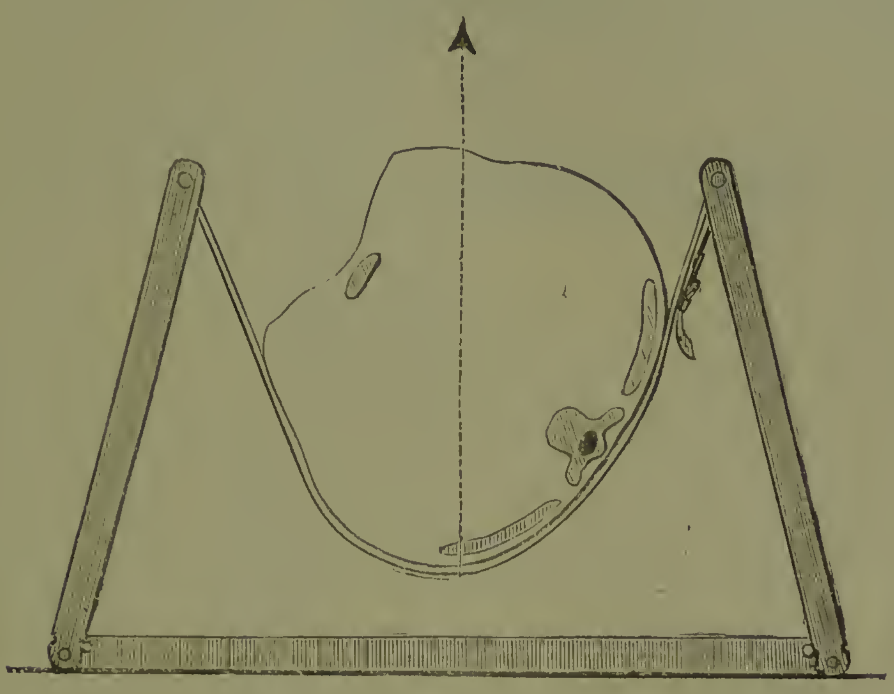


FIG. 19.

position is by no means a disagreeable or wearisome one. During the night a position of rest may be maintained by means of a leathern strap, which proceeds from one corner of the basal-board, surrounds the left shoulder loosely and returns on the other side to the board, where it is fastened by a button or a buckle. This apparatus should be used the whole time of sleeping and for about two hours of rest in the afternoon.

This apparatus is the most effective of all those applied in the treatment of skoliosis. It far surpasses the extension beds as well as all the apparatus with lateral pressure pads hitherto invented. Its use is attended with no real inconvenience; the side position is easily endured, especially when care is taken

that the crest of the pelvis is not pressed too much by the mattress, but receives sufficient support by a cushion placed beneath it. The pressure, though very effectual, is not severe, as the band has no sharp edges and accurately adapts itself to changes of position, whilst the direction of pressure, as the accompanying diagram shows, is precisely the one desired, namely, from the right and behind towards the left and forwards, as is the case with no other apparatus ; the front of the chest is free from all pressure, as the weight of the body itself effects the counter-pressure ; in the same manner, the abdomen and pelvis remain free from all constricting bands as the lumbar portion is acted on by the weight of the body; in short, this apparatus unites all the most desirable features : great simplicity of construction and corresponding cheapness, very energetic action with but slight annoyance to the patient. After the experience I have had of the results of this apparatus I am able thoroughly to recommend it.

We may combine lateral pressure with extension. For this, however, only the second pressure apparatus above described, namely that by *Heine-Carus*, is suitable. This may be applied without any difficulty, as the accompanying illustration (after Schildbach), fig. 19, shows, exhibiting its use as well with an extension bed as with the inclined plane. But whether advantages result from the combination of extension and pressure great enough to render it desirable is uncertain. Though extension for the treatment of skoliosis has still a considerable number of advocates among medical men, yet it must be acknowledged that this plan is being gradually replaced by that of pressure, which will probably supersede it altogether shortly.

The application of apparatus in the upright position of the body is as follows : simple suspension of the body by means of Nück's collar, with the addition of shoulder straps, or without them, has been used very extensively since the introduction of orthopædics at the end of the last century. The idea which underlies this method—a very plausible one—is, extension of the vertebral column by the weight of the body, which certainly acts so long as the body is in a suspended position. It became gradually recognised, however, that this effect is not a permanent one, and even that immediately upon the transition from

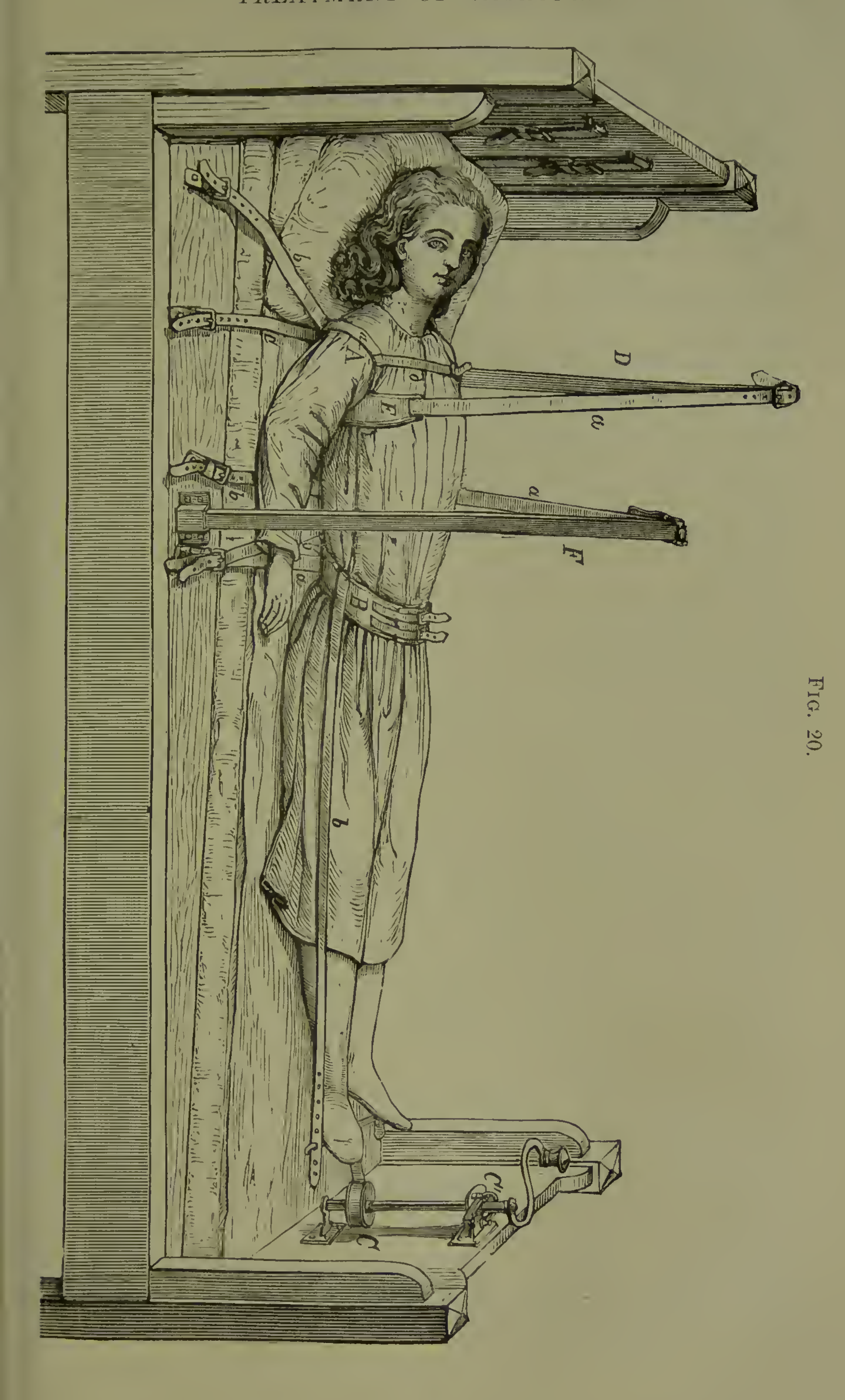


Fig. 20.

suspension to a firm position, an injurious after-effect occurs, because the body, its muscles and ligaments being over-stretched, has so much greater inclination to sink together again into the curved position. On this account, *vertical suspension* gradually fell into disrepute, and Bouvier, in the year 1858, characterised the views generally obtaining on this point not only in France, but also in all the civilised countries in Europe, in these words, 'L'extension verticale par la suspension passive est à peu près abandonnée.' Thus things remained until Sayre [1], in the year 1877 recommended suspension anew under the term 'self-suspension.' The brilliant reception which this old method, published under a new name, received generally, showed that just enough time had elapsed for the results which had been in earlier decades experienced from it, to have been forgotten by the present generation. Nevertheless, the fact itself has not altered in the meantime. Whether the patient produces the suspension by the muscular action of his own arms, or whether it is performed by another person, does not alter the effect, and one may therefore certainly expect that the present generation will experience the same results as the former, not being in any way behind it in thoroughness and patient observation, and that self-suspension will again return to the oblivion from which Sayre has drawn it.

In the second place, *orthopædic chairs*, with extension apparatus or with side-pressure plates must be mentioned. The first apparatus of this sort comes from Levacher de la Feutrie, and since that time many experiments have been made in constructing chairs, in which, either by means of a pole rising up with crossbeams at the head, a half-suspension is afforded, so that the ischial tuberosities only slightly touch the seat, or else spring-pressure plates, with springs attached to the chair, press against the convexity of the curves. Even couches and carriages have been fitted up with similar apparatus. The leading idea here has been to employ extension and pressure, without being obliged to adopt the horizontal position with its deleterious after-effect. All these attempts have now completely passed into oblivion. The form of the chair which is now recommended for skoliotic patients is an ordinary chair, with a firm, comfort-

[1] Sayre, *Spinal Disease and Spinal Curvature.* London.

ably broad cane seat, with a back somewhat obliquely inclined backwards, which is sufficiently high to afford rest and support to the back, and finally two padded arm-rests, the height of which is so graduated that the elbows easily rest upon them. Thus all the necessary orthopædic qualifications are obtained.

There is still one device to be mentioned, which appears to have been extensively used in the French orthopædic institutions about 1830 to 1840, viz. crutches. Two crutches were given to the patient which were so high that when he was vertical they prevented his feet from touching the ground. In order to progress with these crutches, the patients were obliged to place them obliquely on the ground before them, and then, using them as springing poles, swing themselves forward until the feet again touched the ground, and so on, by which means, after some practice, a tolerably rapid progression was accomplished. It is easy to understand the principles upon which this plan was based: the object was to procure a movement of the body by which the vertebral column should not be permanently burdened, but always released from weight after a very short interval, the crutches bearing the burden of the body by means of the shoulder girdle, whilst the vertebral column was extended by the weight of the body. The idea is correct, but it is to be feared that the bad effects of the use of the crutches may be so great as to more than counteract the favourable results. We may instance the well-known crutch-pressure paralysis of the arms, which, however, the patient becomes less liable to when he has had some practice with these supports. Another evil is the high position of the shoulders which becomes established after prolonged use of the crutches, and which gives to the body a very ungraceful appearance. It must have looked very curious, as Dieffenbach thought during his stay in Paris, where the young girls were hopping about with their crutches in the garden of the Orthopædic Institute like so many kangaroos. Crutches are no longer used in France in the treatment of skoliosis.

The last group of apparatus consists of those for wearing, namely, corsets or girdles (*ceintures*). These are principally intended to support and to maintain the improvement in position which has already been gained by gymnastics and

the position apparatus. An independent redressing effect upon the defective position of the vertebral column can only be attributed to them in a very small degree. All these corsets have their basis in an iron belt which surrounds the pelvis and consists in its posterior half of a padded piece of iron, and in front of a buckled strap of leather or strong linen. Sometimes the whole belt consists of iron, or rather a steel spring, and is closed in front by a sliding arrangement. The place at which the belt should be applied extends from the upper end of the fold of the buttocks passing horizontally forwards to the front, and then half-way between the anterior superior spine of the ileum and the top of the great trochanter, and ends just above the pubic symphysis. From the middle of the back of this belt a steel bar with the necessary curve rises, or oftener two bars of the same kind, one each side of the vertebral column (in order to avoid pressure upon the spinous processes) to the middle of the shoulder-blades, and are here made fast by shoulder straps. These bars carry the plates for the side pressure. Often two steel bars rise up, one from each side of the pelvic girdle, which have their upper ends furnished with padded pieces for the support of the shoulders shaped to fit the armpits. The form from which all these corsets are designed is Heister's Cross.[1] This consisted of a pelvic girdle, the iron rod rising from it, and the back shield which was fastened by shoulder straps. Hossard, an orthopædic surgeon of Angers, in the year 1838, first attached the side-pressure plate to the ascending iron rod, which he made movable by means of a rack joint, and on account of the oblique direction which he gave to this ascending iron rod, he called it by the name of the 'ceinture à inclinaison.' A few years later Tavernier, of Lyons, described it in detail in 'Notices sur le traitement des difformités de la taille au moyen de la ceinture à inclinaison sans lits à extension ni béquilles.' Paris, 1841 (fig. 21).

Besides corsets apparatus were also used which, in the form of a half-cuirass made out of some solid material, surrounded the back, the hips, and the shoulders, and were closed in front by straps. These were made according to the shape of the patient's body, and when possible upon a good wooden model,

[1] Heister, *Chirurgie.* Nürnberg, 1718.

in such a way as to provide more or less for the improvement which it was desired to give to the back. The material was either thin iron plate perforated with numerous holes, partly to diminish the weight and partly to facilitate perspiration, or from leather strengthened with steel splints.



FIG. 21.

Joerg,[1] of Leipzig, invented a peculiar apparatus. A curved plate, made out of linden wood and padded at its edges, was so applied to the side of the concavity of the dorsal curve, that it found support under the armpit, and upon the crista ilii ; in the middle, however, it did not touch the body. The projecting ribs were drawn towards this plate by bandages. All these apparatus were objected to by Wilson, on the ground that by their firm encircling of the pelvis they prevented its development, as he had often found narrowed pelves in women who had in their youth worn such apparatus for skoliosis, whereas other skoliotic women who had gone through no such treatment possessed pelves of normal size. These fears have been exaggerated. Nevertheless, it is not a good thing to surround a growing pelvis with a firm girdle ; but if the belt is of the right curve, not too heavy, and is well padded, and if, further, it is not fastened too tight, and of course is laid aside at night, we need not fear any hindrance to growth on its account.

As the pelvic belt is that portion of the corset from which the plates for lateral pressure take their bearing, it may easily happen that the belt may be displaced obliquely by the pressure of the plates. There are three ways by means of which the belt may be given a firmer hold. The first, invented by Heather-Bigg, consists of covering its inner surface with plush.

[1] Joerg, *Die Verkrümmungen des menschlichen Körpers und eine rationelle und sichere Heilung derselben.* Leipzig, 1810.

The fibres of the stuff press the body diagonally, and thus secure the belt in its right position. This is a simple but not very effective arrangement. The second mode is the old plan which Fabricius Hildanus adopted in similar cases, viz., the use of two perineal straps which pass from the sides of the girdle posteriorly, and fasten to it in front. The girdle is thus certainly better fixed, but the irritating effects are very annoying. As the perineal straps must be tolerably tight, they easily cause excoriations and must then be loosened. The third means is an iron splint extending from the side on which the pelvic belt has an inclination to rise (which is almost exclusively the left), which splint being furnished with a hinge corresponding to the

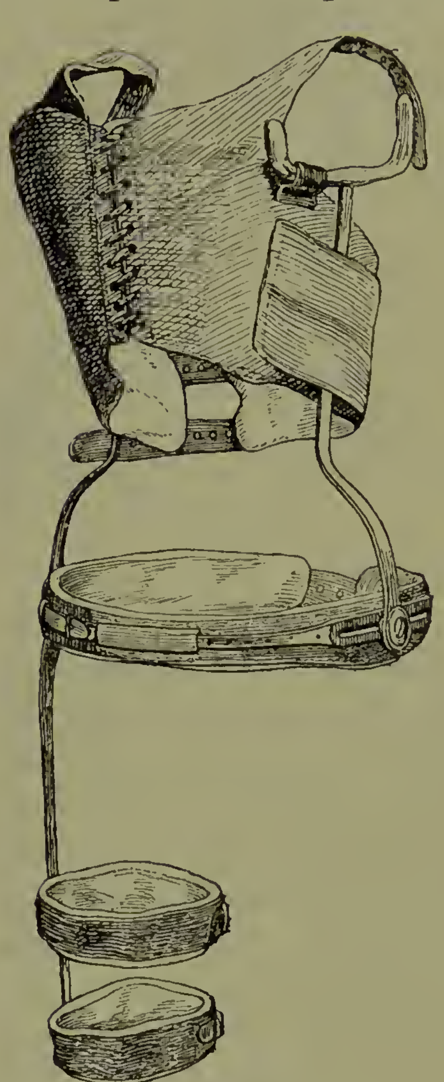


Fig. 22.

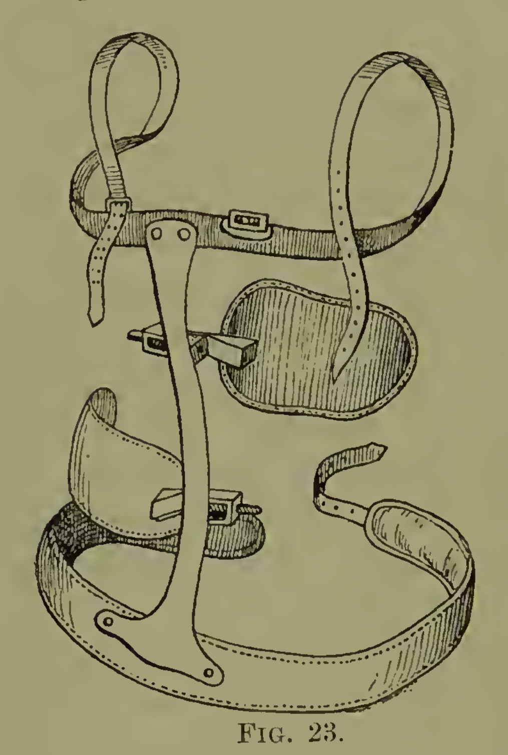


Fig. 23.

hip joint, descends on the outside of the thigh, and is fastened by a leather girdle just above the knee. This is the most effective plan, the long lever of the splint during both sitting and walking considerably increasing the steadiness of the pelvic girdle. In sitting its effect, although not entirely lost, is somewhat less. The long splint descending down the leg is not

uncomfortable, and when the joint in it is well made, and the splint can easily follow the movements of the hip, the patient soon becomes accustomed to it. In any case it considerably increases the pressure of the right-side plate. This splint was known to Bouvier, who however did not prize it very highly ; its principal advocate was Lorinser, who gave it an important place in his skoliosis corset illustrated in fig. 22.

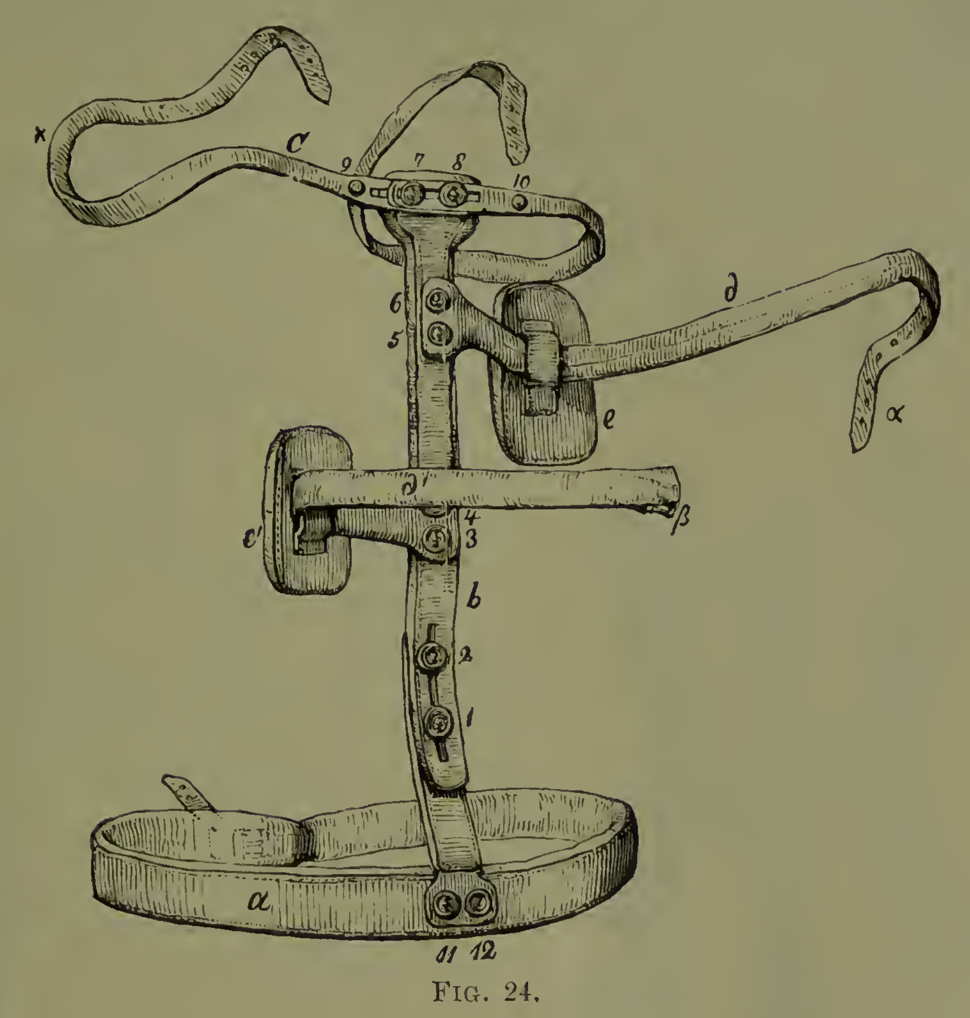


Fig. 24.

The corsets fitted with pressure plates, which are at present most used in Germany, are the following:—

1. An apparatus which is generally called after Heather-Bigg, although previously devised by Delpech. A slight well-padded pelvic girdle, which is placed obliquely corresponding to the inclination of the pelvis from above and behind to below and in front; from the middle of the back of this pass two well-padded steel spring splints (curved in the requisite manner), one on each side of the vertebral column up to

the middle of the shoulder-blades; here they carry a cross-piece, which passes beneath each armpit, curving round in front and ending in straps which pass over the shoulders, and are attached to the back cross-piece. The back splints have at the proper height one or two plates, which by means of spring or screw pressure push against the curves.

2. Nyrop's corset. The foundation of this is in all essentials the same as No. 1, only the plates are fastened differently. They are movable upon two bent springs curved forwards. After the apparatus has been applied, the springs are adjusted to the body, and connected with one another by straps and buckles in front. These curved pieces stand away from the body on account of their spring, and only the plates press against the spinal curves (fig. 24, after Schildbach).

3. The corset with pads (*pelotes*). From the middle of the back of the pelvic belt, two steel rods pass up behind the vertebral column, which are movable by means of rack joints, so that by a key they may be brought nearer to, or removed from, the middle line. The one rod carries at the requisite height the side-pressure plate for the dorsal curve, the other, the one for the lumbar curve. The whole is attached to a corset of coarse linen. After the corset is put on, the plates are pressed against the convexity of the curves by turning the screws. In the severer cases arm crutches also rise from the sides of the pelvic girdle (fig. 25).

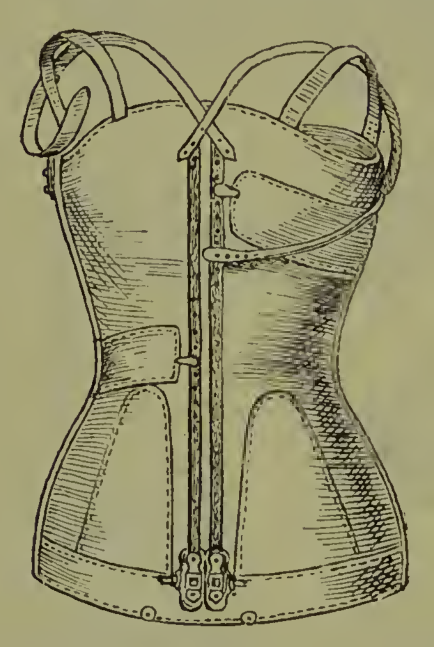


Fig. 25.

I have introduced an alteration into this corset for those common cases of predominance of a severe dorsal curve. In order to secure the pelvic girdle in its place, which is so particularly necessary in these cases, I apply the Lorinser side splint down the left thigh. Now if I were to cause the bar which bears the plate on the right side (a left-sided plate is not generally necessary in these cases) to proceed from the middle of the back of the pelvic girdle,

this would be an unfavourable arrangement of the leverage. Therefore I make the plate bar rise from the pelvic girdle precisely opposite to the insertion of the side splint. It is strongly made, but somewhat springy, and has in the middle a plate made of iron which is large enough to cover the whole of the projecting side of the thorax: the bar is attached by means of a joint. The leverage thus acts by means of three very long levers, which are connected with one another at two right angles. It is in this way continued from the plate

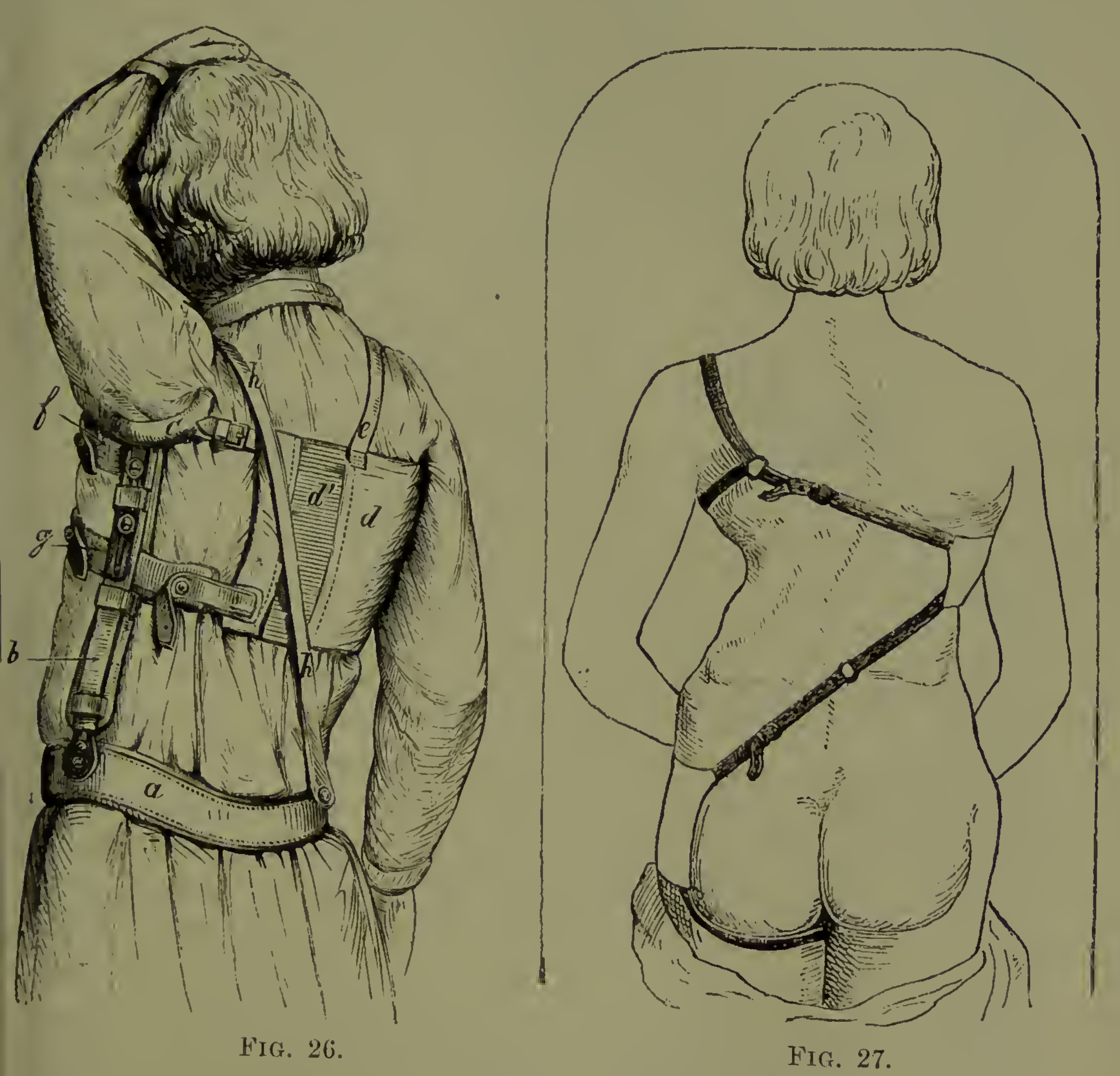


FIG. 26. FIG. 27.

through the bar at right angles to the pelvic girdle, and from this point carried over at right angles to the splint passing down the thigh. I believe that by this means we attain an intensity and constancy of pressure which is greater than in any other apparatus of the kind.

Schildbach has also constructed a portable 'side-traction' instrument, which is made upon the principles enunciated by Joerg. See the accompanying illustration (fig. 26), from Schildbach's 'Die Skoliose:' Leipzic, 1872.

Barwell has invented two apparatus differing entirely in principle from all others; but in my opinion there is a serious fault in their construction. The traction in the first, as the preceding figure 27 shows, made elastic by the use of indiarubber bands, passes from the left trochanter to the projecting ribs of the right side, and from there to the left shoulder. Now wherever two parts are connected by traction, be this rigid, elastic, or muscular, the part which offers the least resistance will be drawn to the other. The question, then, with reference to this traction apparatus is this: how do the resistances of the three parts here under observation stand to one another? The trochanteric region in the human body may be considered absolutely firm against traction. Therefore the protruding ribs will be drawn to it by the elastic tension; on the other hand, however, the protruding ribs are decidedly more firmly fixed than the left shoulder. Therefore it will not be the ribs which will be drawn to the left shoulder, but the shoulder to the ribs. Thus, whilst by the lower pull a slight correction of the curve is effected, the upper traction acts in a decidedly harmful manner, as it moves the left shoulder towards the projecting ribs, and thus gives to the entire upper part of the body an inclination to lean down towards the right. This evil predominates throughout in the action of the apparatus, which on this account cannot be considered effective.

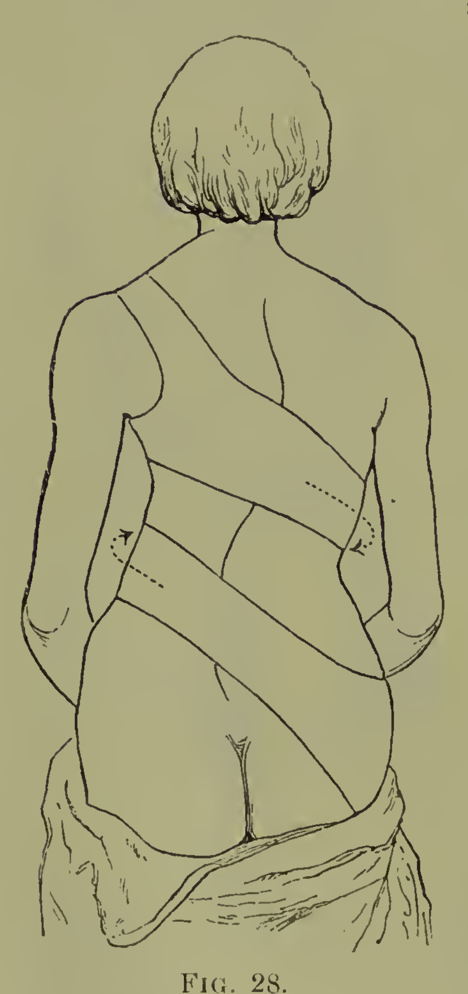


FIG. 28.

The second apparatus is the spiral bandage. From the right

trochanteric region, where a soft leather plate is fastened by a perineal band, traction (also elastic by indiarubber) is directed to the left lumbar region, and from there obliquely rises over the abdomen to the right protruding ribs, and ends at the left shoulder. The apparatus is calculated to exert pressure against the convexity of both curves. But here again the question arises, where is the firm point from which the action must be developed? If the shoulder were as available in this respect as the thigh, nothing could be objected to in this apparatus apart from the passing of the traction over the abdomen; but the shoulder is very movable. Consequently the traction proceeding from the trochanteric region twists the whole body, so that the left shoulder is turned more to the back, and the right farther to the front. The patient will, supposing that this traction is made very effective, twist his right shoulder forwards when he advances with a level pelvis, and that is the worst thing which can happen to a skoliotic patient. For these reasons, I believe that neither of the apparatus invented by Barwell can be recommended.

A new and very lively impetus has been given to the whole question of the treatment of skoliosis by the introduction of the plaster of Paris corset by Sayre, by means of which attempts are made to preserve any improvement in position which can be attained by the vertical suspension of the body. The application of the plaster corset is very simple. The body of the patient is only clothed in a knitted vest; a wadded cushion (the dinner-pad) is laid under this vest upon the abdominal region, and is intended to provide for free play to the changing conditions of the abdomen by its removal after the stiffening of the bandage. The removal of this cushion is effected by means of a long strip of bandage which has been previously stitched to it. If the patient is a girl whose breasts have already begun to develop, a small round wadded cushion, also furnished with a band for subsequent removal, must be laid over each breast. The knitted vest must fit faultlessly to the body, and the projecting bones, especially the spinous processes, must be protected by pads. All these preparations must be made very carefully first, as if they are left until the suspension, the latter will be continued too long and be harmful

to the patient. Half-a-dozen broad and long gauze bandages saturated with plaster of Paris are laid in warm water (if cold were used it would set less quickly); some strips of stiff leather or thin iron plate lie ready for strengthening the bandage; at least two nurses or attendants must be present, to assist, for it is of great importance that everything should be done smoothly and quickly. When all the preparations are made, then the patient is drawn up by means of the head and chin collar, so high that the tips of the toes only just touch the ground; he seizes the extension cord with his hands, in order to remove the arms from the side of the body, but it is not advisable, according to my experience, to employ the shoulder pieces, as by these the shoulder-blades are too much drawn up. Now, first the pelvis must be enveloped in a number of plaster of Paris bandages, for this jacket, like the corsets, takes its support from the pelvis. The lowest turns pass from the lower part of the sacrum to the top of the large trochanter and in front to the upper edge of the pubic symphysis. These turns of the bandage must lie very smooth and firm upon good padding, then the bandage must be carried upwards with circular turns to beneath the shoulders. If about four large plaster of Paris bandages are required, it is advisable to lay on some strips of stiff leather or thin properly bent iron plates, and then to wind over them the last two plaster bandages. The jacket thus gains in firmness without its weight being much increased. The jacket is finished by a thin layer of plaster of Paris, which smooths the outside surface. As the whole jacket should be as light as possible, it is a good plan to use many gauze bandages and not much outside plaster of Paris. With quick and practised handling, the bandage can be applied in five minutes. The extension cord is now loosened, and the patient is lowered so far as to admit of the heels just touching the ground, whilst the back is still very much stretched. If the patient remains in this rather less trying position for yet some five to ten minutes, then the bandage will have become so firm that it does not break even when the extension is completely withdrawn. The scissors and knife must be used for trimming the edges of the bandage; the lower edge must be so arranged that, when the

patient sits down, it should not touch the upper surface of the thigh, and the upper edge so that it does not press into the armpits. The dinner-pad, as well as the protecting cushions for the breasts, are now, by means of the bands which hang out, withdrawn from between the body and the knitted shirt, and thus some freedom is afforded to the breasts and to the abdomen. It is best now for the patient to seat himself without clothing in some warm place in order to accelerate the perfect hardening of the bandage, by means of evaporation of the water contained in it. If the bandage is well put on and quite dried, it resists all outside action with the exception of wet, and the patient can therefore move about tolerably freely and without difficulty. The carriage of the body is somewhat constrained; the waist in girls strikingly large; but it is difficult even to the practised eye to recognise through the clothes whether the person wears a plaster of Paris bandage or not. Taking nourishment and digestion are performed without any great difficulty, as the expansion of the abdomen has been provided for. Respiration is principally by the diaphragm; and if the bandage is somewhat firmly put on, as Sayre especially recommends, the patient cannot sit upon a wooden bench, as the perineum at every respiration is pushed against the firm seat by the pressure of the descending diaphragm. The height of the body is often increased by the bandage applied during suspension from two to three centimetres, which is explained by the compensation of the curves, and the first impression which both patient and physician receive from the new plan is a thoroughly favourable one. But the conditions alter in the course of time.

As every jacket is worn for from eight to twelve weeks, the knitted vest is gradually soaked with cutaneous excretions; dust as well as cast-off epidermic scales form small deposits of dirt, in which insects assemble by preference, as here they can lead an undisturbed life, as they cannot be got at unless by the blowing in of insect powder; but even this remedy should be only used to as limited an extent as possible, as it tends to increase the deposit of dirt. Gradually, in spite of all care in the application of the jacket, reddened, painful places in the skin occur here and there and especially over the spine, gradually developing into actual sores, and when the

bandage is removed after twelve weeks, all these disturbances are so far advanced that a simple warm soap and water bath is not sufficient to render the body capable of at once bearing the next jacket. We must therefore make a pause of several days or weeks, in order that the disturbances may disappear, and during this time the body loses any increase in length which it showed while bandaged. Even, however, when all this is avoided, when the second bandage is able to follow the first at once, and then the third and fourth in unbroken succession, the accomplishment of which I consider a great feat, how long are the bandages to be continued? Longer than a year neither patient nor physician would think of continuing them, and what then is the result of this long and, upon the whole, rather unpleasant treatment? As good as nothing! A skoliotic vertebral column is no fracture which in a certain time adopts and permanently retains the position in which it is held by the plaster bandage. It is after a year just as weak and unstable as it was before; we may even say it is weaker and more unstable than ever, seeing that its bony as well as its muscular portions have suffered considerably in power of resistance from the long repose, and thus the advantage gained by the treatment is soon lost. Whilst the ulcers, without which it is very seldom that a year's treatment of plaster bandages takes place, are slowly healing, the vertebral column returns to its former condition. Moreover, other disturbances occur. Respiratory movement is always seriously interfered with, and the lungs may suffer an injury which but slowly disappears. But the abdomen and the pelvis are especially endangered. A firm compression, day and night, for more than a quarter of a year, may indeed stop the growth of the pelvis, and thus lay the foundation of subsequent severe hindrances to childbirth, in any case to a higher degree than by the use of the pelvic girdle of a corset which is laid aside at night. The whole development of the internal sexual organs indeed, which is so often and without any external constriction deranged in skoliotic girls, as shown by menstrual irregularities, will hardly be assisted by a plaster of Paris jacket.

What then has secured to Sayre's plaster jacket, in spite of these undeniable faults, the enthusiastic reception which it at first received in nearly all civilised countries, and which

reminds one of the enthusiasm with which Heine's extension bed was received in Paris in the year 1823? The *simplicity* and *cheapness* of the whole method. What then appeared easier than to treat and to cure skoliosis, as one required nothing but a knitted shirt, the extension apparatus, some plaster of Paris bandages, and a little practice in their application? All this could be easily and cheaply arranged with very little preparation. This is the idea which Coulomb[1] expresses in the words: 'Il faut être démocrate, du moins en orthopédie.' A method which without difficulties and expense can be employed at once on any patient must in fact have been considered a great improvement. From this point of view there is not much to be said against the plaster bandage. It is undoubtedly the cheapest method of treatment of skoliosis, and in this respect may well possess a certain permanent value. But whoever can afford it will find in the combination of gymnastics with mechanical treatment a decidedly more effectual method, and one which is attended with fewer inconveniences and even dangers.

A number of modifications have been attempted in the modes of application of the plaster jacket, in order to diminish its attendant deleterious effects. J. Wolff laid over the knitted vest first a silicate bandage, and then a plaster bandage over that. After one or two days the plaster bandage was cut and removed, while the silicate bandage remained in its place. The advantage of this plan is, that the latter is lighter and harder than the plaster of Paris bandage, and thus causes less inconvenience. The provisional addition of the plaster bandage is necessary, because the silicate stiffens too slowly, and therefore must during the first day have some outside support. Otherwise the effect is the same.

The other modifications are directed against the immobility of the plaster bandage; they aim at a method similar in principle but with a removable jacket. With this view Beely[2] introduced a hinged removable plaster jacket, but

[1] Coulomb, *Du traitement des Déviations de la colonne vertébrale.* Paris, 1881.

[2] Beely, 'Ueber Anfertigung articulirter zwei- und dreischaliger Gypsverbände zur Behandlung von Erkrankungen der Wirbelsäule,' *Berl. klin. Wochenschr.* 1880, No. 15.

afterwards abandoned this plan. Then there appeared another material, which seemed to unite the advantage of plasticity and immobility, namely, the poroplastic felt. The Englishman Cocking in the year 1870 introduced splints made of felt, to which by soaking in gum or rosin he gave a tolerably high degree of firmness. These splints, when treated with hot water, or in the case of rosin with hot air, became plastic, and could be adapted precisely to the limb, and when cold preserved the form thus received. By these properties, poroplastic splints for the treatment of fractures, and partially also for joint inflammations, were tolerably extensively used in England. Now when Sayre in 1877 brought out his plaster bandage, and a short time afterwards the evils attending the use of this bandage became known, the attempt was made to replace the plaster of Paris by the poroplastic material. It appeared, however, that a simple felt plate could not be used for this purpose, for, when it was attempted to lay this in a soft condition round the body of the patient, a number of creases and folds were produced, which in a short time did mischief by pressure. Upon the rules given by W. Adams, Ernst, the representative of Cocking, made an attempt in the year 1878, to form the felt first upon a wooden model shaped like the human form, and then to place it after warming upon the body of the patient. In this way a tolerably smoothly fitting felt corset can be made. The jacket must be heated in a specially constructed gas oven, at a temperature of 180° F. (100° C.), in order to make the material supple. The patient, clothed in a knitted jacket, is suspended in the manner already described, the warmed felt jacket pressed on to the extended back and closed in front by buckles. After cooling, which soon occurs, and which restores to the felt its original hardness, the jacket ought to keep the back in its extended position. Every evening the patient may lay aside the jacket, every morning he should practise self-suspension, and in this position have the felt jacket put on firmly, and then he can walk about in it during the day. This plan of treatment, however, did not answer. The moulding of the softened felt upon the body of the patient was a very imperfect process, and not seldom burns occurred, from the felt having been overheated. Furthermore,

the material was, unless of great thickness, very unstable, and consequently very soon became bent, whereupon the jacket ceased to afford any support. The daily suspension was extremely troublesome ; the thick impermeable material, from its firm compression, caused too much inconvenience ; and thus, after only a few years, the felt jackets disappeared gradually and are now but seldom used.

Beely[1] has introduced an improved plan of applying plastic felt jackets : he hangs the patient vertically, and then applies smoothly to the naked body a thin bandage of plaster of Paris muslin, divides it, as soon as it is hardened, down the middle line in front, removes it carefully from the patient without breaking it, and closes the bandage again by a newly applied plaster of Paris muslin roller. In this way he gets a tolerably correct model of the form which the body of the patient presented in the suspended position. Upon this model an accurately fitting corset of undressed soft felt is made by cutting out wedge-shaped pieces and sewing the felt together at the intervals, and then the felt, when it has been firmly secured to the model, is made firm by soaking it in an alcoholic solution of shellac.

The edges of the corset are left soft, in order to avoid any hurtful pressure. Some slender and thin steel strips are riveted upon the outside of the corset in order to increase its strength. Perspiration is somewhat facilitated by a number of punctured holes, and in the front middle lines the corset is closed in its lower half by firm buckle straps, and at the top with strips of indiarubber. In this form the corset has been very useful, and is a notable addition to the supporting apparatus suitable for the back. Certainly it possesses the unpleasant fault of being of thick impermeable material, yet there are cases in which its application is beneficial.

In the treatment of the third degree of skoliosis, in which the curve has increased to a humpback, we must lay aside all thought of cure or even of diminution of the curve, and devote our endeavours to guarding against an increase of the evil, and to alleviating the inconveniences caused by it. These inconveniences consist principally in severe pains, which are caused

[1] Beely, 'Zur Behandlung der Pott'schen Kyphose mittelst tragbarer Apparate,' Volkmann's *Samml. klin. Vorträge*, Nr. 199. 1881.

by the pressure of the distorted bones upon sensitive parts, and to the interference with respiration and circulation. The means of alleviation consist in a supporting apparatus, which diminishes the excessive pressure as much as possible, and in the horizontal position, which relieves the spine from superincumbent weight.

There are two periods which demand especial care, viz. those of childbed and old age. At the end of pregnancy and after the birth the resisting powers of the bones and ligaments, not only of the pelvis but also those extending from the pelvis to the vertebral column, are considerably weakened. If the spine is straight and if its bones have suffered no other previous disease, the normal firmness soon returns, which is a protection against curves. Sometimes, even in these cases the softening spreads over a large portion of the skeleton, and then the disease called puerperal osteomalacia develops itself with all its horrors. If, however, the vertebral column has suffered much previously by deformity of its bones and ligaments, the disease finds a prepared ground upon which it develops so much the more easily, and under the influence of the weight of the upper part of the body an increase of the curve is produced. It is therefore necessary to keep skoliotic women in the later period of pregnancy, and after the birth, a longer time in the horizontal position than is requisite in ordinary cases. It is further necessary not to permit such women to rise without an apparatus for the support of the trunk. In a similar manner to childbed, old age exercises a weakening effect upon the powers of resistance of the bones, and therefore one frequently sees skoliosis even of slight degree which has caused but little inconvenience, increase in old age in an alarming manner. In these cases too it is necessary, by frequent adoption of the horizontal position, to relieve the spine from weight and to guard against over-fatigue.

The apparatus best suited for support, so long as the symmetry of the trunk has not suffered too much, are corsets with spring steels. If, however, the hump protrudes very far, it is no longer possible to prepare such apparatus from measurements; it is then necessary to procure a model which will serve as a basis for the work. Such a model is best made of

wood. We can take a plaster cast of the body in a partially extended position, and after this get it copied in wood, which, however, cannot be done without considerable cost. Beely's, plan described above, of procuring a hollow plaster of Paris model of the body, is more simple, but is not so easy to work upon as wood. The material which is used for the supporting apparatus itself is either a corset with properly bent steel splints fixed into it, or a leathern apparatus with numerous perforations in it to allow for perspiration, and the addition of slender steel strips to ensure greater firmness. The cheapest, though not the pleasantest, is the plastic felt stiffened by shellac, after Beely's method. By means of these supporting apparatus we are, in fact, able to remove a considerable portion of the inconveniences, and to make the patient's existence tolerable, even in old age. This is all we can do in these cases.

Inflections of the vertebral column=**kyphosis** may be produced by three causes namely; (1) by the forcible rupture of the connection of the vertebral column in the form of *luxation* or *fracture*; (2) by inflammatory destruction of the bodies of the vertebræ, *spondylitis*; and (3) by *carcinoma* of the vertebræ.

Of these three causes however, the second occupies the most prominent position from its frequency and also from its surgical importance and that to so great an extent, that passing over the two other causes we generally only think of spondylitis when we speak of kyphosis, and therefore we shall exclusively refer to this form of the disease.

The knowledge of this process was first developed (according to some scanty information in Greek and Latin authors) during the seventeenth and eighteenth centuries by the researches of M. A. Severinus,[1] Theophilus Bonetus,[2] Hunauld,[3] Petit,[4] Du Verney[5] and others. Attention was, however, chiefly drawn to this disease

[1] M. A. Severinus, *De abscessuum recondita natura*, lib. vi.: 'De gibbis, valgis et varis et aliis ab interna vi varie luxatis.' Naples, 1632.

[2] Theophilus Bonetus, *Sepulchretum sive anatomia practica*, 'De gibbositate, lib. ii. p. 170. Geneva, 1679.

[3] Hunauld, *Quæstio medica an ab ictu, lapsu, nisure quandoque vertebrarum caries.* Paris, 1742.

[4] Petit, *L'art de guérir les maladies des os.* Paris, 1705.

[5] Du Verney, *Maladies des os.* Paris, 1751.

by the work of Pott,[1] so that since that time spondylitis has been called malum Pottii, or Pott's kyphosis. The process which gives rise to this form of kyphosis consists of a destruction of the vertebral bodies and intervertebral discs caused by chronic inflammation, which produces a more or less considerable defect. This defect can never be replaced, but may be closed up by cicatricial formation. Thus the only possibility of definite cure lies in the formation of a callus at times rich in bone, which causes coalescence of the diseased tissues into a uniform porous bony mass. Since at the time when the defect of the vertebral bodies develops there occurs a sinking together of the row of vertebral bodies under the influence of the weight of the body, the spinous processes of the one or more diseased vertebræ protrude backwards from the row of the bones and form the gibbus (ὑβός), from which the disease has received the name of kyphosis. As far as regards the fundamental character of that morbid process which produces the destruction of the vertebral bodies, it was for a long time a question whether it was to be considered a simple inflammatory or a specific inflammatory, or indeed a tuberculous, or in rare cases even a syphilitic process. Even at the time of Hippocrates this question had been discussed, and it has been repeatedly re-debated. In this century particularly Delpech, Nichet[2] and Nélaton[3] have pronounced decidedly in favour of the tuberculous character of this inflammation. But they did not succeed in obtaining a general acceptance of this view. Quite recently, however, by the help of the microscope, which shows clearly the tubercle in the tissue of the softened vertebral bodies, and as well as by Koch's discovery of the specific bacteria of tubercle, the tubercular nature of spondylitis has been definitely proved. But doubts still exist as to whether all cases of vertebral inflammation must be regarded as tuberculous, or whether, along with the great number of tuberculous cases there may not also be some of simple inflammation. As we are now able to decide with certainty by the microscope whether an inflammatory process is tuberculous or not, we may expect the answer to this question from the investigations of the next few years. In the principal number of cases of Pott's kyphosis, however, the tuberculous character has been undoubtedly established.

Pathological anatomy reveals in the diseased part a centre of softening which is composed of the destroyed spongy bony

[1] Pott, *Remarks on that kind of palsy of the lower limbs which is frequently found to accompany a curvature of the spine, and is supposed to be caused by it, together with its method of cure.* London, 1779.

[2] Nichet, 'Mémoire sur le mal vertébral de Pott,' *Gaz. Méd.*, 1835 and 1840.

[3] Nélaton, *Recherches sur l'affection tuberculeuse des os.* Paris, 1837.

tissue, the detritus derived from the intervertebral discs, and pus. Amongst these fine granular products of destroyed tissue are often found small and perhaps large sequestra from the neighbouring living structures either quite or partly detached. As in all fungous inflammations of bones and joints, the epiphyses of the vertebral bodies are loosened by destruction of the intervertebral discs. It is, however, very rare for the inflammation to attack the firm bone-tissue of the arches and spinous processes. Even when a whole row of vertebral bodies is destroyed leaving but small remnants, the arches belonging to these remain perfectly intact. The disease shows itself under two different forms, viz., either central or peripheral caries.

In central caries the seat of the disease is from the first situated within a vertebral body and extends thence until it reaches the surface; in peripheral caries on the other hand, the process has a superficial position between the periosteum and the bone, and spreads from thence. In the former case, the vertebral body which is affected sinks gradually downwards as it loses support by reason of the disease, and in consequence the tip of its spinous process appears clearly projecting in the back; in the latter case, on the contrary, the destruction may have reached a very great extent without protrusion of the spinous processes being observable as the vertebral bodies are eroded slowly from without inwards. Cases of the latter kind have, however, a very great disposition to spread. The pus descends for long distances between the anterior longitudinal ligament and the bone, disseminating gradual destruction. It is certainly not, as used to be believed, the pus itself which erodes the bones, but the pus is the bearer of micro-organisms, which when they penetrate into living tissues cause inflammation and destruction. Thus the old idea of the eroding powers of certain kinds of pus has in later times been confirmed, although in a modified manner. Central caries has on the other hand more inclination to localise itself from the commencement in the vertebral body, and, when it extends further it does so by breaking through the neighbouring intervertebral discs. Although the different progress of cases dependent on central and peripheral caries cannot be denied, yet we cannot agree

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with Boyer who for this reason endeavoured to establish the theory of two different types of disease.

The sinking together of the vertebral column in consequence of destruction of one or more vertebral bodies is principally produced by the weight of the body; nevertheless, muscular contraction takes a part in this process, though only a subsidiary one. As in every fungous articular inflammation anomalies of position occur which are undoubtedly caused by muscular contraction (whether this be reflex or spontaneous), so sometimes these muscular contractions occur in cases of spondylitis, influencing the position of the diseased vertebral column. It occurs here, however, in a smaller degree than in other joints, because from the compact mass of the parts involved, weight has a very great influence. Accordingly it may happen that through one-sided contraction of the dorsal muscles a certain degree of lateral deviation may be added to backward projection, the latter being generally in the median line, which may remain after a perfect cure of the process of destruction. In these cases it may be difficult to decide whether the deformity be a kyphotic or a scoliotic one.

The size to which the protrusion (gibbus) attains, as well as the degree of the angle which it forms, depends upon the number of the vertebral bodies destroyed. At the apex of the protrusion there is almost always to be found a very sharply defined spinous process, and this, for the most part, corresponds with the vertebra first diseased. Upon the curve of the protrusion from two to three sharply projecting processes may appear; this indicates that very severe defects have occurred in several vertebral bodies, or that the gibbus shows a perfectly uniform course, without any sharp projection, in which case it may be difficult to decide whether it is caused by spondylitis or osteomalacia.

The seat of the disease on the front part of the vertebral column, which is loaded with detritus and exudation, sometimes extends to the front surface of the dura mater and may exert pressure upon it and through it upon the spinal cord and thereby cause symptoms of compression of the latter. The toughness of the dura mater enables it to withstand the corroding influence of the suppuration for a long time, and so long

as the dura mater remains intact, the spinal cord with its delicate covering is tolerably well protected against an invasion of inflammation; gradually, however, the suppuration or rather the micro-organisms contained in it, attack the firm substance of this membrane, the latter becomes perforated and the suppurating matter is effused freely into the spinal canal, whence the inflammation spreads to the pia mater and the spinal cord itself. Apart from collections of exudation, the spinal cord may also be pressed upon by projecting edges of bone. As stated in our description of scoliosis, the spinal cord tolerates very well the effect of slowly increasing curves of uniform course even when these become very severe, as it adapts itself to the altered conditions of space and continues its functions undisturbed. Angular bendings, however, are very prejudicial to the cord. If a vertebral body is gradually so far hollowed out by central caries that only a thin layer of compact substance remains, this may be broken through by a very slight accident, and a sharp bony edge may, as in traumatic fractures, be so displaced that it will press against the spinal cord. In such cases the conduction is interrupted in the spinal cord, whereby sudden paralysis ensues of those nerve-roots proceeding from the cord below the place of injury. On the other hand, however, the spinal cord in spondylitis may escape this danger, and we often have opportunity of seeing very severe kyphotic humpbacks without the slightest nerve-disturbance. The nerve-roots also may suffer considerable disturbance from extension of the inflammation or from compression; if however, a definite cure follows, these disturbances generally recede, and we often find in macerated vertebral columns after old healed spondylitis the intervertebral foramina considerably wider than usual. Definitive cure of the disease occurs through bone-proliferation, which proceeds from the neighbouring osseous tissues which have been stimulated to proliferate excessively, excited by the progress of the inflammatory irritation. By this means the diseased portions are welded together into a uniform bony mass, in which, even after vertical section, it is impossible to distinguish the number of the vertebral bodies. Only the arches and the spinous processes, which also coalesce in this bony mass, give any indication of the number of the vertebræ which have

been involved. In order that the healing may take place the dead tissue at the site of the primary disease must be removed, so that the neighbouring bones may become united to each other.

Now there are two ways in which the removal of the dead parts may take place, namely, either by external evacuation, or by absorption into the fluids of the body. Evacuation externally may either take place at some spot in the neighbourhood of the disease, or it may occur at a place far removed from it. Abscesses of the first sort are called *sessile*, those of the second sort wandering or *congestion* abscesses. I shall refer to these two kinds again later on.

But we also often see cases of severe spondylitis cured without any abscess having appeared. In these cases it is probable that the detritus and suppuration-products have been absorbed slowly in a finely divided condition by the vessels of the surrounding tissue. It even appears possible that large sequestra of spongy tissue may gradually disappear in this manner in the course of a very long time. The manner in which this happens corresponds with that by which dead bones and pieces of ivory as well as pieces of soft organs hardened in alcohol are gradually absorbed, as we have lately learned from the investigations of Senftleben and Tillmanns.[1]

Multinucleated giant cells penetrate into the clefts and crevices of such parts, and reduce their size by gradual absorption of minute fragments. The giant cells themselves appear, when they have finished their work by complete dissolution of the foreign body, to become changed again into connective tissue, from which they have probably been developed. In this manner very large masses of dead tissue may be removed, and thus the hindrances to a cure, which may have existed for a long time, disappear.

It often happens that thickened masses or small sequestra are enclosed in the callus. This sort of healing is, however, not one to be relied on, for slight accidental causes may lead in these cases, even after the lapse of many years, to a new outbreak of the inflammation. Under these circumstances the dead parts, with perhaps a considerable quantity of fresh exuded matter, are discharged externally in the same way that shreds of clothing or fragments of bullet which are often

[1] Virchow's *Archiv*, vol. lxxvii. p. 78.

enclosed for many years in a fracture callus, are expelled with considerable inflammation.

Inasmuch as the spinal column forms the backward projecting gibbus, it would naturally, unless the parts above changed their mutual positions, cause the face to be inclined towards the ground. As this position, however, is a very inconvenient one, the patient strives against it by muscular action. He increases the forward curvature of the cervical vertebræ, and thus keeps his head in an upright position. By persevering in this habit, in the course of years this position gradually becomes fixed through alteration of the bones as well as of the intervertebral discs, and the backward convex gibbus is now partially compensated by a forward convex curve of the upper parts of the vertebral column. Thus is caused the peculiar carriage of the head, which severely kyphotic people generally exhibit. The collapsing vertebral column, when the seat of the disease is in the dorsal portion, presses together the whole bony framework of the thorax. The ribs approach one another and sometimes almost touch. In disease of the lumbar portion, the last ribs descend into the iliac fossa, the sternum protrudes like a wedge. The thoracic and—when the disease is situated low—the abdominal cavity is much diminished in vertical diameter. Thence result pressure and symptoms of congestion of the viscera, which resemble those already described in severe skoliosis, and therefore need not be further discussed here.

The aorta follows the vertebral column, and often forms a tolerably sharp bend at the seat of disease.

With respect to the frequency with which the vertebræ are affected with caries, there exist ample statistics. The most extensive of these is by Menzel,[1] and is founded upon the post-mortem records of the Vienna General Hospital from the year 1817 to 1867. Amongst these 52,256 post-mortem examinations are to be found 2,106 cases of chronic bone-suppuration, of which 1,996 were cases of caries, and 110 were cases of necrosis. These cases of bone-suppuration included 1,295 men, and 811 women. The cases of caries are divided as follows :—

[1] Menzel, 'Ueber die Häufigkeit der Caries in der verschiedenen Knochen,' *Arch. f. klin. Chirurgie*, vol. xii. 1871.

Cranial and facial bones	205
Vertebral column	702
Sternum, clavicle, and ribs	184
Scapula	4
Shoulder joint	28
Humerus diaphysis	13
Elbow joint	93
Radius and ulnar diaphysis	6
Wrist joint and bones of the hand	41
Pelvis	80
Hip joint	189
Femur diaphysis	31
Knee joint	238
Tibia diaphysis	30
Fibula diaphysis	2
Ankle joint and bones of the foot	150
Total	1,996

From these statistics we perceive that caries is far more frequent in the spongy bones and in the joints, while the diaphyses are but seldom affected. Further, it appears that the vertebral column is more frequently diseased than any other part. In only 22 per cent. of all the collected cases of caries were no chronic disease of the internal organs found. In 26·1 per cent. on the other hand, there was extensive disease of the large abdominal glands, such as amyloid disease, fatty liver, and degeneration of the kidneys, but still more frequently caseous foci ulcerations. Tubercles and cavities occurred in the proportion of 54 per cent. of all cases. Specific miliary tuberculosis without further caseous deposit seldom occurs: for instance there were only a few cases of acute tuberculosis, and most of these were of the peritoneum. Moreover, hydrocephalus and meningitis with or without tubercles were seldom observed.

The average duration of life of those suffering from caries, as recorded of the above cases, varied between twenty-five and thirty-nine years, but with regard to this it must be remarked that hardly any examinations of children under ten are included in this report, so that the average duration of life of patients affected with caries, including those who have died before their tenth year, would be undoubtedly less than that recorded.

It is important to contrast these statistics taken from post-mortem records with those directly derived from clinical observations. Such are furnished by Münch[1] from observations in the hospital at Basle. Of 8,030 patients admitted from 1862 to 1876 into this hospital, 421 suffered from caries and fungous articular inflammations, or 5·2 per

[1] *Deutsche Zeitschr. f. Chirurgie*, vol. xi. 1879.

cent. ; of these 265 or 3·3 per cent. suffered from caries, and 156 or 1·9 per cent. from fungous synovitis. The caries affected the different parts of the skeleton as follows :—

Bones of the head	22 cases	=	8·3 per cent.
Trunk bones	89 ,,	=	33·6 ,,
Bones of the upper extremities .	59 ,,	=	22·3 ,,
Bones of the lower ,, .	89 ,,	=	33·6 ,,
Multiple caries	6 ,,	=	2·2 ,,

In those cases ending in cure, there was an average duration of illness of twenty-seven months, the medium duration of life of persons attacked with caries was reckoned by Münch to be thirty-one years, which corresponds almost precisely with Menzel's results. Acute miliary tuberculosis did not appear, according to clinical observation, to occur so seldom as one would have believed from Menzel's compilation. The most frequent cause of death in caries, however, is slow exhaustion, with chronic nephritis, amyloid degeneration, thrombosis of the veins, and fatty degeneration of the liver and heart. Death resulted as above in 46 per cent. of cases, from phthisis in 38 per cent., and from acute miliary tuberculosis in 10 per cent. In the remainder of 6 per cent. death occurred from different and more accidental complications.

I will here add the aphorism of Hippocrates (sect. vi. No. 46) which caused great difficulties to earlier commentators. It is as follows, 'Qui gibbosi ex asthmate et tussi fiunt ante pubertatem moriuntur.' According to our present knowledge, the free translation of this would run, 'Those who become kyphotic in youth, and at the same time show symptoms of pulmonary phthisis, die before puberty,' and against this dictum not much can be said.

Diagnosis.—Spondylitis, from its first commencement to its close, be this by death, or definitive cure, reveals itself in many different ways. Though the different symptoms, without any sharp outlines, glide into one another, it is desirable for purposes of explanation to divide them into different grades; and decidedly the most convenient division is into three, viz., (1) the primary stage of uncertain symptoms; (2) the stage of decided deformity (gibbus); and (3) the stage of suppuration and paralysis.

In the commencement, the altered appearance of the patient, or we may say of the child—since spondylitis is principally,

if not exclusively, a disease of childhood—strikes the eye. Instead of indulging as usual in lively and cheerful play, he becomes sullen and avoids all activity. He is easily fatigued, and sits or lies down in order to rest. He relieves his back from weight by leaning with his elbows on a chair, or places his hands firmly against the knees, for the purpose of conveying the weight of the upper part of the body directly to the thighs. He is unwilling to stoop to lift objects from the ground, and when he does make the attempt, he does not bend forward in the ordinary manner, but lowers the body by bending the hip and knee joints, holding the vertebral column straight, seizing the object, and raising himself carefully by straightening the joints of the lower extremities, whilst he endeavours to keep the vertebral column as immovable as possible. A practised eye will recognise the beginning of spondylitis simply by the manner in which a child does this, almost certainly without further examination. At night the child sleeps restlessly; he groans, grinds his teeth, and often utters a piercing shriek without waking. If the child is taken up and asked what is the matter, he is unable to give any reason for his crying; but only wishes to be laid down again as soon as possible. In the course of time the child becomes distinctly conscious of a pain, which is localised in very different places. Most frequently it is situated deep in the epigastrium, often also in one particular place in the back, or occurring as painful contractions in the legs. If we undress the child, and examine the row of the spinous processes, there is no projection of any one of them to be seen; but if we feel them, pressing a little on each one, or percussing them with a finger, a definite pain will often be produced in one particular place. In the beginning of this century, an old and well-known means for discovering the seat of pain, consisted in the use of a sponge wrung out of very warm water, but not so hot that its touch was painful to the normal skin. Now if this sponge were passed slowly down the spine, the seat of the commencing spondylitis was indicated by the child beginning suddenly to cry when that place was touched. Now if the back is strongly bent forwards, whereby the spinous processes appear more distinct under the stretched skin, one of them sometimes appears more prominent than

the rest. From the combination of these symptoms we are sometimes able, even in this stage of the disease, to determine the seat of the disorder, with some probability, even if a certain diagnosis cannot be made. This last is only possible when in the beginning of the second stage, the point of any particular spinous process projects from the rest. In course of time the prominence of the gibbus becomes steadily more distinct and wider, very often also, though not always, two new symptoms appear, which are characteristic of the third stage, viz. suppuration and paralysis.

The differential diagnosis only presents difficulties in the first stage, and it is the commencing pain which may especially give rise to errors. Acute, or chronic muscular rheumatism, especially lumbago, may simulate for many weeks and even months, a commencing spondylitis, as, on the other hand, a spondylitis may be mistaken for lumbago. It is just the same with rheumatic diseases of the cervical muscles, with respect to spondylitis of the cervical portion of the vertebral column. Pains in the stomach caused by gastric ulcers or other diseases may also be taken for spondylitis, and the reverse. Intercostal neuralgia may be the consequence of commencing spondylitis, or may seem to be so. Diseases of the spinal cord with radiating pains such as tabes and sclerosis in their first obscure beginnings often rouse suspicions of the commencement of spondylitis. The deep-seated pain, as well as the general discomfort which is caused by aneurism of the aorta, may be mistaken for spondylitis, and *vice versâ*. In its further course, when the aneurism erodes the vertebral column and the movements of the back thus become painful, the similarity may appear more striking, but at this stage the pulsating tumour generally affords a clear means of diagnosis.

If we have evidence of tuberculosis elsewhere, or if clear signs of scrofula exist, we have good reason for forming a diagnosis of tuberculous spondylitis, even when its symptoms are still very obscure.

If the back, especially with children, has suffered any injury: a blow, a kick, a fall against the edge of a step, a severe shock from a jump from a great height, a bending together of the body from carrying a weight too heavy for the age; and

if after any of these accidents the first obscure symptoms occur, then this fact is a decided support to the diagnosis of commencing spondylitis. It is not to be denied that apparently unimportant injuries may be the cause of vertebral inflammation, but the conditions are generally such that we must admit the injury to be only the accidental cause which produces the outbreak and the localisation of the disease in a patient predisposed by the scrofulous or tuberculous diathesis. A strong healthy child will not easily be attacked by spondylitis in consequence of such injury, whereas, on the other hand, a child with clear signs of scrofula may very well thus acquire a spondylitis, from which it would probably without the intervention of this injury have remained free.

But even healthy children may, if the injury be sufficiently severe, suffer from spondylitis in consequence. We must then assume that at some point of the vertebral column, by means of extravasation of blood, or crushing of the tissues, a focus either dead or weakened in its vital power of resistance has been produced, which forms a favourable seat for the development of micro-organisms, and thus, if these micro-organisms, even if in such small numbers that the health is not disturbed by them, exist in the blood of the patient, it will afford specially favourable conditions for their colonisation.

Next to traumatic causes acute infectious diseases form the most frequent cause of spondylitis. Whooping cough, scarlet fever, and particularly measles, which are so often followed by tuberculosis, not seldom lead to spondylitis. The relation in which the prior disease stands to its sequence must be explained similarly to that in the case of injury. With regard to the recognition of the commencing protrusion of a spinous process we must remember that the spinous process of the seventh cervical vertebra projects normally distinctly beyond the rest, which circumstance has caused the name of *vertebra prominens* to be given to this vertebra. Again, the uniform posterior curve of the rickety back, which has been already described, must not be mistaken for the sharply defined protrusion of kyphosis.

The skoliotic humpback is distinguished from the kyphotic in that it always shows a marked lateral deviation, whilst the

latter almost without exception keeps the middle line. In rare cases, however, the kyphotic humpback from muscular spasms, as we have remarked in our description of the pathological anatomy of this disease, may likewise exhibit a lateral deflexion of the column, in which case the diagnosis is not easily established.

Curvatures from osteomalacia may, when the spine keeps precisely to the middle line, and the disease is attended with acute pains, be with difficulty distinguished from spondylitis; nevertheless, here the protrusion of one single spinous process, which is almost always clearly marked in spondylitis, is absent. Also the other symptoms of the case are generally available for the differential diagnosis.

Suppuration at the focus of disease occurs, indeed, in all cases of spondylitis, but does not always make its appearance outwardly. Considerable collections of pus may be perfectly absorbed without becoming visible in any place, but in severe cases, with wide-spread destruction of the vertebral bodies, it often happens later on that large collections of pus will become apparent. These may make their appearance either in the neighbourhood of the place of their origin: in which case we designate them by the name of sessile abscesses; or they appear in parts of the body which are far removed from the focus of the disease. The latter kind are called congestive, migrative, wandering or gravitation, abscesses.

The course, which these collections of pus take, depends upon a variety of conditions. These are chiefly due to the anatomical formation of the tissues concerned, such as the spaces of loose connective tissue, and the arrangement of the compact fasciæ and aponeuroses, the latter being seldom penetrated by these abscesses.

Gravitation and muscular contraction exercise a material influence.

For the most part gravitation decides the course the pus will take; it sometimes, however, happens that the collection, when it arrives at an impassable barrier, may, by the action of the surrounding muscles and under the influence of the progressive tension caused by the increase of the suppuration, move in a direction opposed to gravitation. Sometimes the

abscess breaks through its capsule either by slow ulceration, or by suddenly bursting in consequence of a violent movement of the body—a fit of coughing for example—and effuses itself into some neighbouring organ. In this way perforations may occur into the pleura, the bronchial tubes, the œsophagus, the colon, the rectum, the vagina, the bladder, or other parts.

As a consequence of the anatomical conformation of the parts which are invaded, these gravitation abscesses follow certain fixed routes : as such are to be considered in the first place *ilio-femoral* abscesses. In this case, the pus coming from the lumbar or lower dorsal vertebræ, ascends behind the parietal peritoneum upon the psoas muscle or in its substance, and emerges under Poupart's ligament through the opening of the crural ring. It then proceeds through the foramen ovale of the fascia lata under the skin of the thigh, and may here form a large swelling. So long as these abscesses are still situated behind the peritoneum, their diagnosis may present great difficulties, but they generally become apparent when the patient flexes the hip-joint in consequence of tension of the psoas muscle, and if we place the hip-joint in extreme flexion, so as to relax this muscle, we often by pressing deeply with both hands can feel distinct fluctuation in the fossa iliaca.

If the abscess begins to appear outwardly by a slight protrusion in the neighbourhood of the crural ring, the diagnosis can no longer be a doubtful one, as now we can, by alternate pressure above and below Poupart's ligament, feel undoubted fluctuation, a symptom which occurs in a similar manner in no other condition than that of these gravitation abcesses. If a large portion of the abscess is already clearly perceptible on the thigh, both to sight and feeling, a very short examination is sufficient to establish the diagnosis.

The second typical wandering abscess is the *ischio-femoral.* In these cases the pus has descended into the true pelvis from the fossa iliaca, and then from there has made its way outwards through the large ischiatic notch along the sciatic nerve.

We find in this case at first a distinct projection of the skin and an obliteration of the fold lying below the gluteal muscles, and gradually a large, distinctly fluctuating swelling appears

at this place. The deep-seated position of these abscesses under the gluteal muscles renders their diagnosis in their early stage difficult; and inasmuch as they cause the hip-joint to be flexed, and the gluteal fold to bulge downwards, it may be at first impossible to distinguish with certainty these abscesses from commencing coxitis. The pus may also penetrate the posterior wall of the capsule of the hip-joint, to which it is immediately adjacent, and by entering the articular cavity this joint may be further included in the disease.

The abscesses passing down upon the psoas muscle sometimes wander from their regular course, and pass in between the layers of the wall of the abdomen, where the firm Poupart's ligament (which here has no natural opening) interferes with their course downwards. In these cases the pus collects either in the abdominal wall, or it sinks through the natural opening of the inguinal canal into the scrotum, and may here be mistaken for an inguinal hernia.

The abscesses which originate in the bodies of the upper cervical vertebræ sink downwards into the loose connective tissue, which lies between the anterior surface of the cervical vertebræ and the pharynx. These are therefore called retro-pharyngeal abscesses; but here it must be remarked that not all retro-pharyngeal abscesses are gravitation abscesses which come from a diseased vertebral column. Very often these are nothing but suppuration of the loose connective tissue without any bone disease. The protrusion of the pharyngeal wall narrows the way for air as well as for food and drink, and thus produces dyspnœa and dysphagia, which may both cause very alarming symptoms; these symptoms, however, at once disappear when the abscess is opened.

The abscesses in the thorax which are formed from disease of the dorsal vertebræ either sink down along the aorta, through the aortic aperture of the diaphragm into the abdominal cavity and then along the usual course upon the psoas, or if the way downwards is closed to them they ascend. They may then become outwardly visible at the upper thoracic aperture external to one of the sterno-mastoid muscles, or they may wander in the loose connective tissue which accompanies the nerves of the brachial plexus between the first rib and clavicle into the

cavity of the axilla. They may also even proceed to the outer surface of the parietal pleura along the ribs to the front, and appear at an intercostal space, even close to the sternum. Abscesses of the first sort demand an immediate opening as soon as they are perceptible externally, as they may cause sudden suffocation by pressure upon the windpipe, or even by perforation into it.

If the abscess remains in the locality where it commenced, it gradually makes its way along the vertebral arches under the muscles, and after breaking through the fascia appears under the skin of the back. At first a small protrusion appears which, in the course of time, may assume very considerable dimensions.

If these abscesses are left to themselves they may in the most favourable cases, although very rarely, disappear by absorption. But in most cases after existing some time they break through the skin by one opening or very often at several places simultaneously, and then discharge a slimy non-odorous matter mixed with flakes and *débris*, which often contains fine bone-particles, sometimes even large sequestra. The last condition decides absolutely the fact that the matter originates in a diseased bone. After the opening has occurred the condition of the pus alters with tolerable rapidity, it begins to smell unpleasantly in consequence of its decomposition. The general condition of the patient, which before the opening is very often but little disturbed, becomes bad, fever occurs accompanied by great discharge and diarrhœa, and the patients often die with these symptoms. This sudden collapse of the general health which occurs after the bursting of the abscess is the reason why there has always been an objection to the opening of these abscesses.

The diagnosis of gravitation from other abscesses or swellings, is generally easy, as the distinct gibbus, which is almost always present in these cases, affords a plain indication from the first. But in extensive peripheral caries, in which the gibbus may be entirely wanting, we are deprived of this assistance to diagnosis; although we should bear the fact in mind, in order to protect ourselves from error.

Paralysis is an event which often occurs in the later periods

of spondylitis. This condition belongs chiefly to nervous pathology, and need, therefore, only be so far described here as may be necessary from a surgical point of view. Between paralysis and congestive abscess there exists a certain antagonism; that is, the cases in which large collections of matter form and descend freely, are proportionately seldom affected by paralysis; and, on the other hand, abscesses are absent when paralysis occurs. This relation, however, is not constant, for we may find both conditions present together, and sometimes we observe that very severe paralysis will recede when a gravitation abscess becomes outwardly perceptible.[1] Paralysis seldom takes place suddenly; generally it is preceded for some time by peculiar sensations in the lower extremities, a feeling of numbness, formication, dragging pains and muscular spasms. These symptoms increase until at last complete paralysis takes place.

This affects either both motion and sensation, or only motion, and in very rare cases sensation exclusively. This predominant derangement of the motor function is explained by the fact that the anterior columns of the spinal cord, which are attacked in the first place, as well as the anterior nerve-roots are motor, and thus, when the vertebral column is bent, they alone—or if the pressure affects the whole thickness of the cord, also the posterior sensory parts—are injured.

The paralysis extends, almost without exception, over the whole section of the body, which is supplied by the nerves proceeding from below the diseased part. These are almost always the lower extremities, and sometimes the bladder and rectum. Often a portion situated higher up is paralysed, whilst the lower portions remain intact. It thus sometimes happens with spondylitis in the cervical region that one arm, or still more rarely both arms, become paralysed, whilst the parts lying lower down remain unaffected. In these cases we presume that the injury has affected the nerve-roots more than the spinal cord itself. The paralysed muscles are generally relaxed, and preserve their excitability to faradisation. Some-

[1] I believe the explanation of this supposed 'antagonism' to be that when an abscess burrows away from the seat of disease, the inflammatory progress or the direct pressure of the abscess may be removed from the neighbourhood of the spinal cord, and thus the cause of the paralysis be also removed.—N. S.

times, however, involuntary convulsions occur in the paralysed parts, and isolated muscles may even be permanently spastically contracted. If the conduction in the spinal cord be entirely interrupted, then the paralysed portions show increased reflex excitability, so that slight touches unperceived by the patient may provoke strong contractions. We see the same symptoms in animals when the spinal cord is divided. The course of the paralysis is a very varied one; it may slowly recede as it has slowly developed, when gradually sensibility as well as mobility returns. It may even happen that increase and retrogression of the paralysis may follow one another several times. If a definitive cure of the bone disease takes place, the paralysis generally subsides. Yet many patients, and especially children, die of the disturbances which are the consequence of interrupted functions of the spinal cord: such, for instance, as bed-sores, cystitis, &c.

The cause of the paralysis is to be sought in two directions: either in pressure upon, or in extension of inflammation to, the spinal cord. So long as the dura mater remains intact, the inflammation seldom extends to the cord. If, however, this membrane be perforated or softened, and the tuberculous matter be effused into the cavity of the spinal canal, and mix there with the cerebro-spinal fluid, an acute inflammation follows, not only of the parts directly concerned, but of the whole extent of the cord, even up to the brain, a condition which always proves fatal.[1] The pressure may be produced either by sharp edges of bone or by very tense exudations. It is in the latter cases that the paralysis disappears when the matter finds a free outlet, and thus the pressure ceases. Sharp edges of bone which press against the spinal cord, or even spiculæ which penetrate its substance are less readily altered. Yet even in these cases by means of the gradual rounding off of the bone by absorption as well as especially by the diminution of the displacement by treatment, the symptoms may improve considerably.

In the treatment of Pott's kyphosis we have two objects in

[1] I am inclined to consider that in many of the cases of paralysis the dura mater is not perforated, because after fixation of the spine these cases have been known to recover comparatively rapidly.—N. S.

view: first to preserve life, secondly to cure the defect in the vertebral bodies caused by the ulcerative destruction as soon as possible, In attempting the second object we must never forget the first, in attempting to remove the deformity we must not put the life of the patient in peril, which may, indeed, sometimes happen. Even without any surgical treatment a not inconsiderable percentage of spondylitic patients get well. These patients will walk about if allowed, as long as they are able, and even under such circumstances some of them recover. If walking becomes too painful for them, they take to bed and remain there until they feel strong enough to move about again, and definitive cure may gradually follow in the course of some years. In these cases the deformity is always very great, and much greater than would have been the case if proper treatment had been adopted.

For hastening the cure of the disease, the antiscrofulous regimen takes the first place in the treatment. Light, good nourishment, cod-liver oil, quinine and iron; and in cases where there is a suspicion of syphilis, iodide of potassium; good country air, letting the child lie in the sea-sand warmed by the sun, also the use of mud baths are amongst the special means employed. For local applications oily liniments, the principal consideration in the use of which is the mechanical effect of the rubbing for the dispersal of the exudations accumulated in the tissues. Spirituous lotions, or stimulation of the skin by tincture of iodine or blisters; the last remedy seems specially able to remove injurious matters, which collect in the blister, a theory which is not improbable according to the bacterial pathology of the present day. Rather large blisters on both sides of the gibbus are produced, and renewed repeatedly. Hueter recommended a two per cent. solution of carbolic acid to be injected by means of Pravaz's syringe once or twice a day, i.e. one to two grammes of the solution directly into the bony tissue. Although much experience supports the idea that the carbolic solution, when applied in the right place would have a favourable effect, yet in spondylitis the local conditions are of such a kind that there is great danger in inserting the needle deep into the tissues. We must direct the needle from the back obliquely past the

spinal cord to the vertebral bodies, and it may easily happen that the spinal cord or its envelopes will be penetrated, which, even if not directly fatal, cannot but have an injurious effect. Therefore this method of treatment of spondylitis cannot be recommended. On the other hand, covering the diseased part outwardly with a compress of a two per cent. solution of carbolic acid is a simple proceeding. It reddens the skin, and from its volatile nature it is by no means improbable that some of it may penetrate into the tissues, and there act antiseptically.

We can promise no advantage from cold applications, or the removal of blood. The last weakens the patients, who cannot spare any blood, as they have before them a long and exhausting illness, and the effects of cold must be still more doubtful in so chronic a disease.

In earlier days a very important *rôle* was played in the treatment of spondylitis by external derivatives in different forms: caustics, setons, issues, moxas, and the actual cautery. This treatment is to be ascribed especially to Pott, who warmly recommended such methods. This treatment was a favourable one with the Arabs. Pott maintained that he was able to cure by these means all cases of the disease in its early stages, whilst all cases of spondylitis treated without derivatives he said, were sure to die—two statements which are obviously untenable.

The great influence which Pott during his life, and even for a long time after his death, exercised upon the progress of surgery, led to cauterisation being, even up to the middle of this century, the favourite method for the treatment of spondylitis, especially as Rust also in the most energetic manner declared himself in favour of this remedy in all cases of fungous bone and articular inflammation. Not until between 1860 and 1870 was this method gradually discontinued, and for the reason that it gave great pain to the patient, and in its effects was far from being worthy of the estimation in which Pott, Rust, and many others held it. In the present day there is no longer any question of reintroducing the practice of cauterisation in any form as a general remedy in the treatment of spondylitis, but, there are isolated exceptional cases, in which we may be *disposed* even now to apply the actual cautery.

These are cases in which deep boring pain and reflex muscular spasms are present. Both symptoms may in fact be ameliorated by a tolerably severe cauterisation on both sides of the gibbus performed under chloroform. The freshly burnt surface is covered with an oil compress and after the falling off of the scab the granulating surface should be dressed with slightly irritating ointments such as red precipitate ointment, so that the healing results in from six to eight weeks. But even in these cases, in which the favourable results of cauterisation are clearly apparent, the disadvantages of a surface wound in the first place and then of a scar next to the gibbus, have to be encountered. The patient could not very well be allowed to lie on his back, or at least special arrangements would have to be made for this position, so that there should be no pressure upon the wounds, and in walking about the use of a supporting apparatus would be impossible. Therefore it is well to avoid cauterisation almost entirely.

So long as the patients are able to walk, we should allow them to do so, but not without a supporting apparatus, which relieves the diseased part of the vertebral column as much as possible from superincumbent weight. Permanent lying in bed has an injurious effect upon them, they lose appetite, the digestion becomes disturbed and strength decreases. Slight exercise in the open air affords an essential element of life to these patients and must be permitted them as long as possible. On the other hand, any other muscular activity whatever, even in the form of the mildest gymnastics, should in the active stages of spondylitis by no means be recommended, as it would be very injurious. If, however, we were to leave the vertebra column unsupported during walking, violent pains would be caused by the pressure of the upper part of the body and also in the course of time a very considerable deformity would take place. It is, therefore, necessary to relieve the vertebral column from the superincumbent weight by means of a supporting apparatus, which transfers the greater part of the weight from the portion of the body situated above the diseased place directly to the pelvis, and even by posterior leverage of the upper portion of the back to effect a compensation of the already existing displacement.

Peter Camper was a staunch advocate of a supporting apparatus, and since his time the construction of such apparatus has become practically perfect. Besides the simple but accurately fitting corsets with shoulder crutches, which are sufficient for the slighter cases, there is a special apparatus invented by the American Ch. F. Taylor,[1] which acts in a superior manner. From a pelvic girdle proceed two iron bars, one on each side of the vertebral column, with the requisite curve to the level of the gibbus, and are there connected by means of a hinge joint with two other bars which ascend to the upper edge of

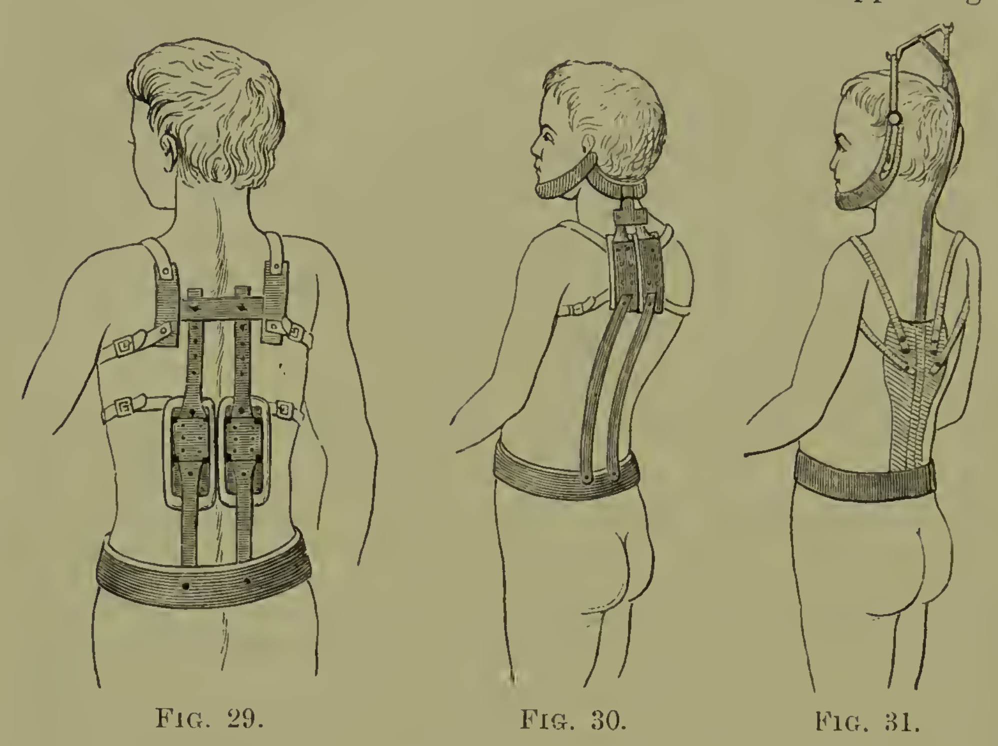


FIG. 29. FIG. 30. FIG. 31.

the shoulder-blades, and are fastened by shoulder straps. On both sides of the gibbus lies a long pad covered with plush in order that the necessary pressure for redressment should not act upon the top of the gibbus but at its sides (see fig. 29).

With this apparatus a most favourable support can be given when the spondylitis is situated in the three upper lumbar or the six lower dorsal vertebræ, and these are the regions in which it most frequently occurs.

Spondylitis of the two last lumbar vertebræ is particularly difficult to support, as the lower lever arm is too short. The row of the upper six dorsal vertebræ is equally difficult to control, because the upper lever arm is too short. For these, as well as for the cervical vertebræ an apparatus is used which rises above the head and supports it by a

[1] Taylor, *The Mechanical Treatment of Angular Curvature, &c.* New York, 1870.

collar. Taylor made an attempt to arrange his machine for these cases also, so that it should rise to the back of the head, and from here support the under jaw with a stirrup from below rotating upon a vertical axis, as the accompanying illustration (fig. 30) shows. This modification has not, however, proved available; it is therefore better, in spondylitis situated high up, to use the Minerva machine (fig. 31) described in the treatment of scoliosis, and by this means to relieve the upper part of the vertebral column from weight. At night the patient should rest in the horizontal position upon a firmly padded mattress, and—especially when the cervical vertebræ are diseased—with a slight weight extension to the head.[1]

In the year 1877, Sayre recommended his plaster of Paris jacket for spondylitis (see treatment of scoliosis). In cases of disease low down he carried the bandages to the middle of the shoulder-blades, for those higher up he added to the plaster of Paris bandage a 'jury mast,' i.e. a frame made of a thin strip of steel, which passed over the head in two arches and surrounded and supported the head from below, like the Minerva machine. In the application of this jacket the patient must be suspended vertically, but, as Sayre points out, we must only stretch him so far as can be done without causing pain. For spondylitis, as in the case of scoliosis, the plaster of Paris jacket seemed at first particularly favourable, because it fits closer than the splint apparatus, and produces a more perfect support and unloading of the diseased parts; but further experience proved the evil effects of this treatment in cases of spondylitis even more clearly than in cases of scoliosis.

Besides the fact that children with disease of the cervical vertebræ sometimes die suddenly during suspension from displacement of the bones against the spinal cord, or from pressure of an abscess upon the windpipe, as has happened with Sonnenburg and others,[2] bed-sores are also especially to be feared in these cases. Besides the ordinary prominent bony points there is also the gibbus, which is only covered by thin tender skin and upon which, even after careful padding, large sores may be found after removal of the jacket, and

[1] Mr. Chance's instrument, fully described by me in *The Surgery of Deformities*, possesses all the good points of Taylor's and has other advantages. Whatever instrument is used, its effect depends greatly upon the adjustment and manipulation of the surgeon, and, therefore, that which may be employed successfully by one surgeon will fail in the hands of another, who may succeed with some other apparatus.—N. S.

[2] *Verhandl. d. deutsch. Gesellsch. f. Chirurgie*, 10th Congress, 1881, p. 23.

the bones may even become exposed to a considerable extent. In consequence of these unpleasant occurrences the supporters of the plaster of Paris jaeket have been gradually alienated from it, and in the present day—four years after Sayre's publication—very few surgeons in Germany prefer the plaster of Paris bandage, and these do so principally because of its cheapness for hospital patients.

The felt jacket has been used for spondylitis as well as for scoliosis, although in these cases it has also been attended by a number of evils, which are caused by the impermeability of the material of which it is made and its want of rigidity ; and these evils have gradually lessened the use of the felt jacket. On the other hand, Beely's modification of it certainly possesses great advantages for spondylitis and especially for those cases which cannot be sufficiently supported by Taylor's machine ; its use is therefore in some cases highly desirable.

If the patient in consequence of violent pains or from paralysis can no longer walk about, we must then have recourse to permanent recumbency. This involves three conditions : first, to remove the pressure, which the diseased bones exercise upon one another ; secondly to secure a slight separation between them and thus to favour the development of the healing granulations ; and thirdly, as far as possible to fix the diseased part so that consolidation may proceed undisturbed. Of these three indications the second must not be overdone. However favourably a slight separation of the diseased bones may act upon the healing in the vertebral column, we must be most careful to avoid allowing the distance to become too great, as otherwise in these cases a scanty amount of granulating tissue will not suffice to fill up the gap. At least a very much longer time would elapse before perfect cure could take place, and having regard to the exhausting effect, which vertebral caries exercises upon the body, it is very important that the disease should terminate as soon as possible. Under these circumstances it is better to put up with a moderate amount of projection when by such means a more rapid cure results, than to endeavour to remove the deformity and thus to protract the cure.[1]

[1] In England at least the opinion prevails that the diseased parts should *not* be separated. Pott was the first to point out that a natural cure with

The most simple means of fulfilling the three conditions mentioned above, is the horizontal position upon a well-padded horsehair mattress. Superincumbent weight is thus removed from the diseased parts sufficiently, and even a slight separation of the diseased surfaces of bone is effected, but this means alone is quite insufficient for producing fixation. For slight cases it may be effectual, but in severe cases further measures are necessary. As such Bonnet's *half-cuirass* is to be mentioned.

A half-circle of thin iron plate or wirework accurately fitted to the body of the patient, and well padded, surrounds the whole of the back from the sacrum to the seventh cervical vertebra, and when the disease is situated in the cervical vertebral column, the apparatus includes this part also and the head. Three bands surround the pelvis and the shoulders respectively, and a fourth, the forehead; two handles, one at each side, are so fitted that the apparatus, and with it the patient, can be raised without allowing any movement to take place in the vertebral column. Corresponding to the place at which the gibbus is situated a hollow is made in the apparatus in order to avoid as much as possible the production of sores.

The apparatus does in fact immobilise the vertebral column to a much greater extent than does the simple horizontal position, and moreover it enables us to move the patient from one place to another much more easily, for making the bed and defæcation, thus presenting great advantages and forming a very valuable assistance in the treatment of spondylitis. When the cure has so far advanced, from rest in this apparatus, that the back has attained sufficient firmness, the patient may get up and walk about, with the help of one of the supporting apparatus already described.

Lying upon the stomach, either freely in bed or in such an apparatus as that just described, arranged for the front surface of the body—the 'prone system' of the English—was in former

firm coalescence would probably be interfered with by attempts to straighten the spine. Bonnet of Lyons discussed this point in his peculiarly practical manner and urged that if it is undesirable to separate the parts yet it is of the utmost importance to relieve the diseased surfaces from excess of pressure, *i.e.* from the pressure of the superincumbent weight, and this view is generally upheld in this country, although the means adopted to carry it out may not always be successful.—N. S.

days much preferred to any other position, in order to facilitate cauterisation and the subsequent prolonged process of healing on both sides of the gibbus, an operation which was considered necessary. This reason has now ceased to exist, as cauterisation is at present so seldom performed, but lying upon the stomach may even now become necessary, when abscesses have opened upon the back, as in this position changing the bandages, and keeping the wound clean, are more easily performed. Nevertheless, those who know the sufferings produced by long continued lying upon the stomach, will only decide on having recourse to it in the very last extremity.[1]

The second means of immobilisation is extension. This increases at the same time separation of the diseased surfaces

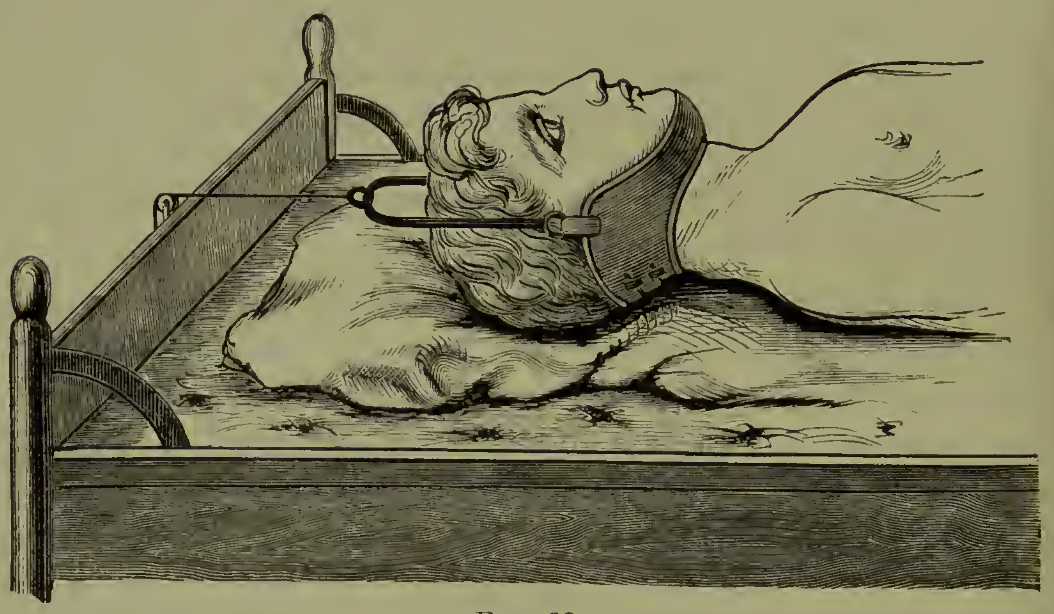


Fig. 32.

of bone. By extension and counter-extension the degree of movement, as in the case of joints, is considerably diminished, and also when any movement does take place, the bones, being kept apart, do not rub together and thus do not cause any irritation. We must not, however, carry the extension so far as to

[1] From a very considerable experience of the prone position I can say that, with rare exceptions, children suffering from spinal caries are not only greatly benefited as regards the cure of the disease, but that they find the position very much more comfortable than any other. It is important, however, that the couch be properly constructed upon the pattern originally devised by Verrall.— N. S.

cause too great a separation. If the cervical vertebræ are diseased, it is sufficient to apply to the head by means of the head and chin collar an extension weight of from 2 to 3 kilos., in the manner invented by Volkmann (fig. 32). The body effects by its weight a perfectly sufficient counter-extension. If the disease is situated lower down the vertebral column, the extension at the head must have a counter-extension at the pelvis in the manner described for scoliosis, yet in the latter situation in the vertebral column it is less necessary to have recourse to extension, because the horizontal position or Bonnet's half-cuirass are sufficient and less wearisome.

The third plan for the compensation of displacement and for immobilisation consists in pressure against the gibbus.

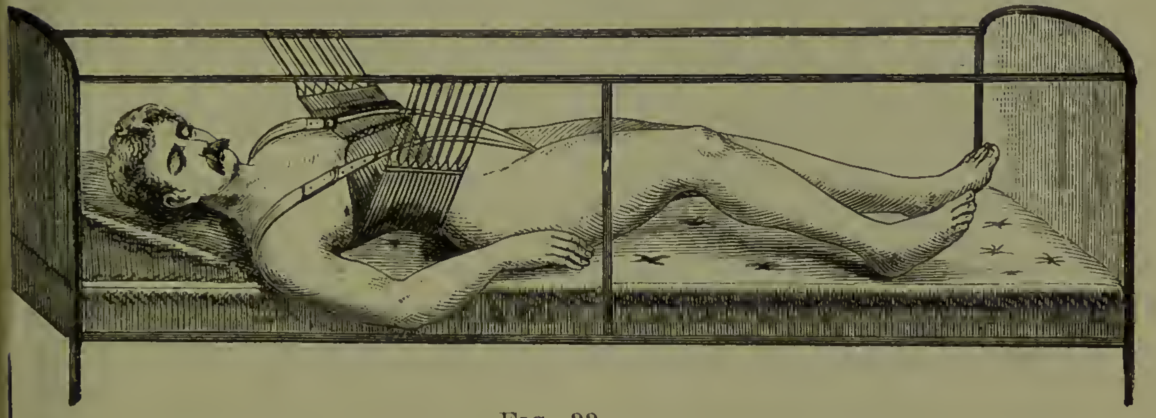


Fig. 33.

This is exerted either by an oblique cushion placed so as to bear upon the gibbus, a means which has been known for a long time and has recently been especially recommended by Maass and Scriba[1]; or else by the slinging girdle invented by Rauchfuss,[2] in which the patient lies on his back with the gibbus in the sling. Both these plans, and in fact the whole principle upon which they act, seem to me to overshoot the mark. The gibbus is a point which is very unsuited even for the mildest and softest pressure, as bed-sores are almost certain to occur after a time, and then this bearing of the vertebral column upon a firm resistance is a proceeding which makes the defect of the vertebral bodies gape to the greatest extent and

[1] J. Scriba, 'Beiträge zur mechanischen Behandlung des Spondylitis,' *Berl. klin. Wochenschr.* 1878, Nos. 28, 29, 30.

[2] Rauchfuss, *Jahrb. für Kinderheilkrankheit*, 1875.

thus must delay the period of cure to the utmost. Besides which, this position is so painful that I do not understand how it can be maintained for long. Who, for example, looking at the accompanying illustration of the Rauchfuss sling, can fail to realise that even a healthy person could not maintain this position for twenty-four hours, and it is proposed that a sufferer from spondylitis shall remain in it for weeks and months! To extend the patient beyond the horizontal position is unnecessary in spondylitis; in fact it is rather to be recommended that a hollow, and not a projection should be made at the place where the gibbus is situated, after the manner of Bonnet's half-cuirass.

When cure has taken place, the case may be considered as done with. Only when the callus is still very fresh and soft, can there be any hope of acting upon it favourably by extension. Any attempt to break the callus mass by forced extension or pressure, and then to allow it to heal in a better position in a retentive apparatus—as may be done in the case of bones of the extremities—is out of the question as regards the vertebral column. The danger of tearing or crushing the spinal cord and the nerve-roots is too great. By good fortune these accidents may possibly not occur, as in the case in which E. Küster straightened a vertebral column very much displaced by fracture,[1] but few surgeons would have the courage, in the face of the possibility of the occurrence of such severe injuries, the avoidance of which is not within the power of the operator, to undertake the *redressement forcé* of the vertebral column. On the other hand, after complete cure, we may favourably influence the carriage of the parts of the body situated above the gibbus, as well as improve the general strength, much weakened by the long illness, by carefully regulated gymnastic exercises.

Paralysis requires partly an electro-therapeutic treatment by faradisation and galvanism, and partly a surgical treatment by removal of the pressure upon the spinal cord as far as this is possible. We endeavour to effect this object by the opening of very tense abscesses, and by the removal of the angular bend as far as possible by vertical or horizontal extension. If the latter can be effected, the paralysis speedily disappears.

[1] *Verhandl. d. deutsch. Ges. f. Chirurgie*, 10th Congress, 1881, ii. p. 104.

Possibly the restoration of the functions of the spinal cord may then be hastened by subcutaneous injection of very small doses of strychnine. Ergotine has also been recommended, but it appears to me that the use of this drug cannot be satisfactorily supported either on theoretical or practical grounds. Even without any other treatment than the horizontal position rather severe paralysis will, not seldom, subside.

The treatment of gravitation abscesses has always been considered very difficult, for if they are opened the pus soon decomposes and the general health of the patient consequently quickly deteriorates, and death often follows. In the first place, therefore, endeavours used to be made to induce absorption of the pus, and doubtless the best means of accomplishing this result are: painting the skin over the abscess with tincture of iodine; compresses with from six to eight per cent. salt solutions and general salt baths, and internal diuretics or iodide of potassium. In fact these means are sometimes successful in producing absorption of even large collections of pus, and we may therefore, even now, although we have much less to fear than formerly from the opening of these abscesses, make the attempt to obtain absorption in this manner. Formerly if the above remedies did not succeed, it was customary to wait for the spontaneous opening of the abscess, but matters were by no means thus improved. The abscess frequently lasted for years and then the skin often became perforated in several places and the decomposition of the pus as well as its effect upon the general health of the patient, were the same as after incision. Surgeons therefore had recourse to the old plan of the Arabians, namely, the opening of the abscesses with chemical or thermal cauterisation or by a seton drawn through the cavity. The unfavourable result was, however, but little altered by the adoption of such methods. As decomposition of the pus was attributed to the influence of the air which entered the abscess, the exclusion of the air was attempted by tapping and by aspiration. The abscess was emptied, but the pus soon collected again, a fistula gradually formed at the place of penetration and the worst consequences resulted. No better success attended Abernethy's method of introducing a small scalpel obliquely through the walls of the abscess into its cavity and

allowing the matter to flow slowly away. The wound closed well, but it opened again later on, and became a fistula. The method introduced in 1849 worked more favourably. It consisted in injecting—after emptying of the abscess by means of a trocar—tincture of iodine, or better, because less irritating, a watery solution of iodine and iodide of potassium into the abscess cavity. These injections were generally followed by a sharp inflammatory reaction, which either led to bursting of the abscess or else to absorption.

These difficulties are now to a great extent removed by the use of Lister's method of dressing, which prevents almost certainly the decomposition of the pus.[1]

The experience of Volkmann[2] and König[3] with respect to these abscesses is as follows:—With antiseptic cauterisation the abscess is first opened under Poupart's ligament, then the finger is introduced into the cavity of the abscess and upon its tip, pushed forwards against the walls of the abdomen on the inner edge of the anterior superior spine of the ilium, a second incision is made. A thick metal probe is pushed through the wound and through the abscess cavity backwards over the crest of the ilium, until it can be felt on the outside edge of the quadratus lumborum muscle through the soft parts, and here a third opening is made. In this last incision only the superficial strata are divided by means of the knife, the deep strata, on the other hand, by means of blunt instruments and especially, according to Roser, by means of a strong pair of dressing forceps, which are introduced closed into a cleft of the tissues and then forcibly opened. Now follows the withdrawal of the tuberculous membrane covering the wall of the abscess by means of a sharp scoop; the wound is then washed out with $2\frac{1}{2}$ per cent. carbolic acid solution; and then a drainage-tube of the thickness of a finger is introduced into each opening. By means of numerous folds of Lister's gauze upon the surface of the abdomen, and a large firmly applied Lister's bandage, an even and firm compression of the abscess cavity is effected. If an abundant secretion follows, it is often necessary in the next few days to wash out the abscess cavity with

[1] The difficulty of applying Lister's plan in these cases has been well pointed out in Holmes' *System of Surgery*. 3rd edit. vol. ii. p. 419.

[2] Volkmann, *Behandl. d. Senkungsabscesse, Beitr. z. Chirurgie.* Leipzig 1875.

[3] König, 'Ueber die Fortschritte in der Behandlung der Pott'schen Kyphose,' *Berl. klin. Wochenschr.*, 1880, No. 7.

carbolic acid (2 to 3 per cent.) or chloride of zinc solution (1 in 30). By this treatment it is generally possible even in a few days to remove the drainage-tube which lies under Poupart's ligament, and soon afterwards that applied to the opening in the region of the anterior superior spine of the ilium, and the third drainage-tube alone remains in its place, by means of which for a long time pus and tissue *débris* are discharged. After some weeks the patient gets up and walks about with a Lister's bandage and the supporting apparatus.

The continuance of the suppuration through the fistula situated in the lumbar region is caused by the presence of necrosed tissue and sequestra in the spondylitic focus, before the entire removal of which the cure cannot take place. Hence we often find in the discharged matter bone spiculæ, or fine bone sand, which feels distinctly gritty between the fingers.

When all these dead portions are discharged—a result which may take months or even years—the fistula closes. But even this cure cannot be regarded with certainty as final: for a few years pain may recur, a new abscess form and again discharge matter containing, as a rule, small pieces of bone.[1] The suppuration may last for a long time, until it gradually dries up. Such relapses, which are probably caused by dead pieces of tissue embedded in the callus mass being expelled after a period of quiescence, often recur several times, until finally there is a definite cure. The principles of the treatment last described may be applied to the treatment of other gravitation abscesses besides the ilio-femoral.

During the last few years we have learnt from v. Mosetig-Moorhof[2] and Mikulicz[3] of a drug, iodoform, which appears to have a great effect upon local tuberculosis, but it would take too

[1] Operations for the direct removal of necrosed pieces of bone have been performed. In England Mr. Treves has introduced the practice of cutting outside the erector spinæ muscle down to the diseased vertebræ when situated in the lumbar region, giving immediate relief to the abscess or removing pieces of dead bone, and when a psoas abscess has pointed in the groin he has made a counter opening and inserted a large drainage-tube. This is a formidable operation, but is doubtless of value in some cases.—N. S.

[2] Von Mosetig-Moorhof, 'Iodoform als Verhandmittel für Operationen wegen fungöser Processe,' *Wiener med. Wochenschr.* 1880, No. 43; 1883, No. 13.

[3] Mikulicz, 'Ueber Iodoform als Verhandmittel bei Knochen- und Gelenktuberculose,' *Verhandl. d. deutsch. Gesellschaft f. Chirurgie*, 1881.

long if I were here to discuss thoroughly the advantages and disadvantages of the use of this remedy.

A lively discussion upon this question is to be found in the 'Centralblatt für Chirurgie,' 1881 and 1882. I confine myself, therefore, to giving a short description of the practical application of this drug.

If an abscess cavity is slow in healing, we put a few grammes of iodoform into a glass tube, introduce one end of the tube into the cavity, and blow out the iodoform by pressing an india-rubber ball, so that the powder is scattered upon the walls of the cavity. If the closing of the fistulous opening is delayed too long, we introduce into it a small stick of gelatine and iodoform, pushing it if possible to the end of the passage. The gelatine gradually dissolves, and the iodoform then comes into direct contact with the granulations. If excessive granulations proliferate, they must be removed with the sharp scoop before the application of the iodoform. If the fistulous passage is very long it may be desirable to make a counter-incision at the end of it, or to divide the whole passage. We then often find in the course of it a piece of dead tissue which has kept up the suppuration. These methods answer better than those previously employed for the same purpose: namely, injection with tincture of iodine or galvano-cauterisation.[1]

If final cure results, the patient may again move about freely, nevertheless he carries the gibbus with him as an irreparable deformity for the rest of his life. If the gibbus is small, he will not be much inconvenienced by it, but the larger it is the greater will be the trouble which it causes.

The shortening of the thoracic and abdominal cavities in their vertical diameter, caused by the bending of the vertebral column, must especially be referred to. It causes symptoms of pressure and engorgement very similar to those which have been described in severe scoliosis, and the dictum of Hippocrates is also true for kyphotic gibbus: 'Multi quidem gibbi facile at non scimus quam bene valentes jam usque ad senectutem id mali sustinuerunt, præsertim quibus corpus carnis plenum ac pingue effectum est; pauci autem eorum ad

[1] I have met with very great success in curing such cases by the daily injection of a weak solution of carbolic acid.—N. S.

sexagesimum annum pervenerunt, plerique enim citius moriuntur.'[1]

Inflammation of the occipito-atloid joint demands a special description. The peculiarities of this inflammation as opposed to the other forms of spondylitis consist principally in that the atlas is connected with the occipital bone and also with the axis not by intervertebral discs, as the other vertebræ are to one another, but by joints, and also that it is in the immediate neighbourhood of the medulla oblongata. So that if the inflammation extends or pressure from a subsequent dislocation takes place, much more serious disturbances will be produced than at other places. The articular connection of the atlas with the cranium is formed by the two saddle-shaped joints of the condyles with the upper articular surfaces of the lateral masses ; the rotating joint of the atlas with the axis consisting of the odontoid process held firmly to the inner surface of the front portion of the atlas by the transverse ligament and of the two lateral joints between these two bones. A peculiarity also consists in the spongy bone-tissue of the atlas being much less than in the other vertebræ, as the body of the bone consists of a tolerably thick crust which contains very little spongy tissue. Inflammation of this joint either exists in the form of rheumatic synovitis or of the fungous proliferation with predominant participation of the bone-substance itself, which has for ages been designated by the name of spondylo-arthritis. Synovitis is characterised by violent congestion of the synovial membrane and increased secretion of synovia, which either preserves its serous qualities or is gradually transformed into pus. In the latter case it may perforate the articular capsule and destroy the ligaments. In general, however, rheumatic synovitis has a tendency rather to cause contraction and coalescence than suppuration and destruction. Consequently fibrous ankylosis frequently takes place between the articular surfaces, and even osseous union between the atlas and occipital bone may occur, so that when the bones are sawn asunder no precise boundary may be found between them, but the spongy tissue of the one passes directly into the spongy tissue of the other. It is

[1] Hippocrates, *De Articulis*, lib. iii.

nevertheless very difficult, when only the bone preparation without any history lies before us, to arrive at a decision as to whether the union has been caused by inflammation of the joint or not; for there appears to be a condition in which, owing to defective formation, the occipital bone and atlas are coalesced into one bone. Ankylosis of the occipito-atloid joint necessarily prevents all movement between the two bones, so that the head can no longer be freely bent upon the neck. The rotatory movement, however, as it occurs in the atlo-axoid joint, remains free unless this joint is also ankylosed. The upper vertebral joints suffer not infrequently from acute articular rheumatism, whereby the movements of the head become very painful; however, the inflammation generally recedes without causing ankylosis.

Fungous articular inflammation is distinguished from rheumatic synovitis, in the first place, by having a much greater inclination to ulcerative destruction. With scanty caseous exudation both the fibrous as well as the bony portions of the joint are destroyed for some distance, so that much displacement may occur in the part under consideration. Moreover, at these sites fungous articular inflammation is very general and almost without exception of a tuberculous character. The real focus of disease is situated either in the middle of the bone and extends from here outwardly, or it is situated in the peripheral portions and extends inwardly. If a portion of the bone is destroyed the head sinks towards the side of destruction. A slight degree of rotation is often added to the lateral inclination, which rotation may be also influenced by the form of the bone destruction or by the reflex muscular action which plays so great a part in the course of all fungous articular inflammations. If the whole occipito-atloid joint be destroyed, the head sinks forwards and thus presses the medulla oblongata against the front part of the atlas. If this dislocation occurs suddenly by accidental force, death may occur at once; if the dislocation happens slowly, the medulla oblongata often adapts itself to the diminished space, without serious functional disturbance. Still more dangerous consequences ensue, when, after destruction of the transverse ligament, the odontoid process presses against the medulla. In this case death

often happens suddenly in a similar manner to that in which it occurs when the dislocation is caused by an accident in the normal joint. The destruction of the bones is often very extensive. Cases, for instance, have been recorded, in which the whole atlas has been destroyed and the occipital bone has articulated with the axis, and even in which a cure has ultimately resulted.

The abscesses in disease of this joint appear either in the neck just under the occipital bone, or they descend at the side of the neck between the muscles, or they are situated on the front surface of the vertebral column and push the posterior wall of the pharynx forward in the manner of the already described retropharyngeal abscess. Also this most severe form of spondylitis is often cured, and when this is the result, no great inconveniences are left behind if there is no severe dislocation, although the movements of the head are very much interfered with.

The diagnosis is made from the localised severe pain, which is increased by movement of the head. Sometimes crepitation is present, which is either experienced by the patient himself, or which is recognisable by an examination through the stethoscope; nevertheless, destruction of the bone often proceeds to a very great degree, without crepitation ever being present, because, as happens so often in fungous granular inflammation, the spongy granulations lie between the rough surfaces of bone. Sometimes the pain radiates from the place of the disease by isolated nerve paths to distant parts. Rust has remarked a very characteristic sign of this disease. As the patient experiences violent pain when he moves his head, he preserves it in a fixed position, not only by strong tension of the cervical muscles, but also by holding the head firmly with his hands, especially when he moves from the horizontal into the vertical position, or the reverse. This sign, in conjunction with the singularly anxious expression of countenance of the patient, upon which Rust also lays great weight, is often sufficient for a diagnosis at first sight. If the patient wishes to look on one side, he does not turn his head, but his whole body. If displacement has occurred, the head, alters its position as regards the neck and remains sunk sideways. Sometimes we can

detect the dislocation by feeling the back of the pharynx with the finger. But we must not be deceived as to the position of individual vertebræ. That cervical vertebra, the body of which is felt when the finger is passed directly through the mouth, is the third. If we wish to examine higher, it is necessary to raise the finger-tip on the back of the pharynx to the level of the posterior nares, where the axis and even the atlas can be reached.

In forming a differential diagnosis we have first to consider muscular torticollis, in which the sterno-mastoid muscle is shortened; but this distinction presents no difficulties. We are more likely to make a mistake when an acute phlegmonous inflammation of the loose connective tissue or the lymphatic glands of the neck occurs. In these cases the head is sunk in order to relieve the inflamed parts as much as possible from tension, and the movements are in the highest degree painful. As the case progresses an abscess soon shows itself, after the opening of which the inconveniences soon cease, and all the uncertainties which may have existed for a long time are removed. Gummata and tumours may also produce the appearance of vertebral disease, yet by observation of all conditions even in these cases the diagnosis may generally be made, although not seldom it requires time.

The treatment of rheumatic synovitis includes sweating, hydrotherapeutics, blisters, salicylate of soda, iodide of potassium. If the radiating pains are very severe or remain after cessation of inflammation in the form of neuralgia, the employment of the constant current is indicated. The fungous inflammation requires the same general treatment as with the other vertebræ. Cauterisations are not generally to be recommended in these cases, but special conditions in isolated cases may render them necessary. The question of systematic movements can naturally only be discussed when the inflammation has finally ceased, and then we must restore the greatest extent of movement possible to the head; yet it must never be forgotten that here we tread on very dangerous ground, and that any excess in movement may renew the inflammation. Naturally, forced correction of position is out of the question after cure in this dangerous situation. The supporting of the head is attained

either by the Minerva machine, or by apparatus of padded iron plate, firm leather, and similar materials, which surround the head in the form of a cravat, and find a wide basis of support upon the upper portion of the thorax, from which they fix the neck and slightly raise the head at the lower jaw and occiput. Matthieu's cuirass, here illustrated, is particularly well known. For the purpose of keeping the head in position in bed, a slight weight extension is best suited, unless we prefer to cause the supporting cravat to be worn also in the horizontal position, which presents great advantages, in so far as it facilitates the patient's raising his head and fixes the cervical vertebral column better. A plaster of Paris bandage round the neck in place of the cravat would be a very unsatisfactory substitute. Felt, rendered hard by being steeped in a solution of shellac, would be better, but this would have to be moulded upon a wooden model.[1]

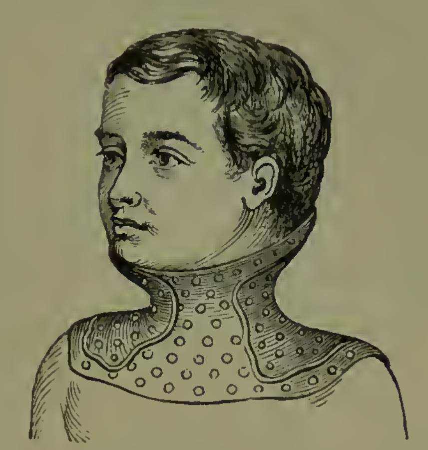


FIG. 34.

[1] A common plan of treatment in England consists in absolute recumbency in the supine position, and support of the head and neck by means of sand-bags; but a mechanical support is more certain in its effects.

Dr. W. J. Fleming of the Glasgow Royal Infirmary has invented a very useful apparatus for fixing the cervical vertebræ. It consists of indiarubber bags in the form of a collar which can be applied empty and then inflated to the desired extent.—*Brit. Med. Jour.*, Jan. 3, 1885.

Mr. Walsham has advocated the use of a stiffened felt apparatus moulded to the head like a bonnet, and made to fit the neck and shoulders.

GYMNASTICS AND MASSAGE

FOR OTHER THAN ORTHOPÆDIC USE IN MEDICINE.

GYMNASTICS as well as massage can be applied with benefit in other departments of medicine than that of orthopædic surgery.

Inflammatory exudations of all kinds, the absorption of which is delayed, may often be more rapidly dispelled by movements and rubbings. At the commencement of every inflammatory process the affected tissues are infiltrated with fluid, which has penetrated through the walls of the vessels from the blood, or, technically speaking, has exuded. The removal of this fluid occurs through the lymphatics, the open radicals of which interpenetrate the tissues.[1] These carry fluid into the lymph capillaries, which are very minute tubes, but already furnished with a special wall, and which by their coalescence form the larger vessels which, gradually increasing, finally open into the lymphatic glands. Here by means of the fine network which the fluid has to pass through, a filtration of the solid particles takes place which, if they have a high specific gravity, are permanently retained in the lymphatic glands—as, for example, the cinnabar granules which are rubbed into the fine punctures of the skin in tattooing, or they may be disintegrated in the glands to fine granules which are gradually carried off by the vasa efferentia. If the solid constituents carried to the lymphatic glands from the seat of

[1] The appearance of separation of individual fibres of connective tissue by effused plasma is well shown in a drawing in the *Atlas of Histology*, by E. Klein, F.R.S., and E. Noble Smith, pl. viii., fig. xiv.; described on p. 33. London 1880.

inflammation are of a bacterial nature they produce inflammation of the gland, and this may eventuate in suppuration, by means of which the collected substances may be discharged outwardly. Those substances which have left the fluid through the efferent vessels have still to pass through a chain of glands before they finally reach the thoracic duct, and from this in a purified form are again mingled with the blood. Whether there are lymphatic vessels which discharge directly into the large lymph channels without the intervention of glands, appears doubtful. If the inflammatory exciting cause, which we in the present state of science must consider in the greater number of cases as consisting of micro-organisms, has already reached a great intensity in the place of the primary inflammation, the exuded fluid collects together with the white blood-corpuscles which have also issued from the blood-capillaries and forms an abscess; by means of the opening of which, either by spontaneous perforation or by incision, the removal of these micro-organisms from the body is effected.

Whether, besides the absorption of the inflammatory exudation by the lymphatic vessels, absorption by the veins also takes place, appears extremely doubtful; in any case, the lymphatics take by far the larger part. If the inflammation has reached no great height, then, after removal of the collected exudation, the restoration of perfectly normal conditions may ensue. In the higher degrees of inflammation, however, as well as in those cases in which it is chronic from the beginning, it leads to the formation of a cicatrix, by which the affected parts are united together. These are the well-known inflammatory adhesions which are so often left behind after inflammation. These adhesions may gradually disappear if the affected parts are frequently exercised. The adhesions are stretched by the movements, and are finally ruptured. The surfaces of the parts become smooth, and their movement can then occur without difficulty. This happy result is not, however, the rule; in very many cases, the adhesions are so firm that they can no longer be removed, but fix the affected parts unalterably together. Both gymnastics and massage have in the treatment of inflammations the double object of hastening the absorption of the exudation as well as loosening,

and, where possible, separating entirely, the connection between the parts caused by adhesion.

As concerns the hastening of the absorption, we know from the experiments carried out for this purpose by Von Mosengeil (79), Lassar (81) Genersich,[1] Paschutin,[2] and others, that centripetal rubbings, pressings, kneadings, as well as movements in the joints, hasten the lymph stream, and thus conduct the collected fluids more rapidly into the tissues. This experiment is quite confirmed in man also. Extravasations and exudations disappear more quickly when they are submitted to this mechanical treatment than if left alone. The increased surface of absorption by means of the dispersal of the collected fluid constituents over a larger area, their conduction towards the centre by the centripetal rubbings, the suction pump action which the muscular movement effects, the increased flow of blood which occurs after every massage, and which exhibits itself by redness of the skin and elevation of the local temperature, are the principal elements of the treatment.

Nevertheless, we ought not to submit every inflammatory exudation to massage. If it has infectious qualities the inflammation may be thus carried into other regions, and by its being conducted into the whole volume of blood, even cause sharp fever with rigors. The most dangerous of all, however, are those inflammations which were formerly called *phlebitic*, but which are now generally designated by the name of *thromboses*. In these cases the spreading is the more to be feared, in that here collections of pus or separated thrombi pass directly into the large veins, and thus may lead to the most alarming symptoms.

It is therefore advisable not to have recourse too soon to massage, but first to wait to see whether in the course of time spontaneous absorption will not eventually occur with assistance from other external remedies, such as baths, bandages, high

[1] Genersich, 'Die Aufnahme der Lymphe durch die Sehnen und Fascien der Skeletmuskeln,' *Arbeiten aus d. physiolog. Anstalt zu Leipzig*, 1870, p. 53.

[2] Paschutin, 'Ueber die Absonderung der Lymphe im Arm des Hundes.' *Ibid.* 1872, p. 197.

position of the affected region, cold water compresses, saline or spirit lotions, iodine, &c. ; and only to have recourse to massage when these means fail, and sufficient time has elapsed for us to hope that the exuding fluids may have lost their infectious properties. Separate remarks upon the different regions of the body are not necessary here, as the conditions are essentially the same in all parts. It is generally the extremities upon which massage is employed for the hastening of absorption of inflammatory exudations. *Acute rheumatic muscular pain* demands a special description. It very often occurs when the heated and perspiring body encounters a cold draft of air on some particular region, or when the affected part has remained during sleep too long in an uncomfortable position producing great muscular tension, especially when at the same time the influence of cold is present. A sudden violent muscular movement may likewise produce this pain. The sacro-lumbalis muscle as in lumbago (the *tour des reins* of the French), and the sterno-mastoid muscle as in rheumatic torticollis, are the most frequently affected. This pain also extends very much over the whole muscular system, and is then called by the country people 'Hexenschuss' or witch dartings. The exact nature of the sudden and usually very severe pains, which for many days, render every movement exceedingly painful and difficult, is still unexplained. They cannot well be caused by an inflammatory exudation, as they occur so suddenly, and their connection with inflammation is therefore not altogether justified. Possibly there is a partial coagulation of the contractile muscle substance. Their course is well known ; even without any treatment the pain disappears after a certain number of days and then free movement returns. The treatment is a very varied one. Repose in bed, wet packings, cuppings, external irritation of the skin, such as by mustard plasters, chloroform, liniments, blisters, subcutaneous injections of morphia, Turkish and especially Russian baths with the hot vapour douche, all facilitate the disappearance of the pain and the restoration of free movement.

Latterly special attention has been directed to the fact that this pain often disappears more quickly by means of massage and movement than by repose and bandagings.

This is an old popular remedy to which science has at times paid great attention. As early as the year 1837, Martin [1] laid before the Société de Médecine of Lyons a mémoire, in which he strongly recommended the treatment of this affection by massage, and mentioned cases in which he had succeeded in completely removing the most violent lumbar pains by one single massage operation, and Bonnet, although with some reservations, agrees with him. Stromeyer [2] relates a case in which a country doctor, who visited his patients on horseback, was attacked after staying some time in a drafty hovel by the most violent muscular pains in the whole body. An old peasant advised him to mount his horse again, as recovery sometimes occurred by that means. He was lifted on to his horse, and the first steps caused him the most violent pain. Gradually, however, he improved, and as a storm was imminent, the doctor hastened his horse's pace as much as he could. He thus became heated and began to perspire, and by the time he reached home the pain had gone.

As regards the *kind of massage*, we commence with slight rubbings with the finger-tips, or the surface of the hand, after the manner of 'effleurage,' gradually followed by stronger rubbings and pressings. Often a strong rubbing with a very hot piece of flannel is enough, or a powerful brushing. Finally we add some movements, in order to convince ourselves of the result of the treatment.

Nevertheless, it must be pointed out that these rapid cures do not always take place. If serious injury is present, such as the rupture of muscular fibre from straining, or a true muscular rheumatism with localised exudation in the form which Froriep calls rheumatic induration, the treatment is not so soon ended, but necessitates long repose in bed, and the functions only gradually return even after the pain is removed.

It is the same with sprained joints. We designate by the name of sprain (distortion) that condition into which a joint is moved by external force beyond the limits of its normal range. Under these circumstances there is formed on the side towards which the movement has occurred, a protrusion of the two bony

[1] Martin, *Du traitement de quelques affections musculaires faussement attribuées jusqu'à ce jour au rhumatisme.*

[2] Stromeyer, *Erfahrungen über Localneurosen*, 1873.

ends forming the joint, and between these points the articular surfaces are separated so that they gape. Now, as an empty space is thus caused in the joint, the external atmosphere presses for a moment a portion of the capsule into the articular cavity. The tendons and ligaments on the side at which the separation occurs are at the same time much stretched, and even partially torn. In the next moment when the effect of force ceases, the joint surfaces come together again, and then occur interpositions of folds of the synovial membrane between the joint surfaces, or when interarticular cartilage discs are present in the cavity, these suffer a displacement. The violent pain which follows the sprain depends partly upon the great straining which the ligaments and tendons and, through these, the muscles, have undergone, and partly by the tearing or the interposition of folds of the capsule between the joint surfaces. Also from the severe tension the tendons may have ruptured their sheaths and may be displaced over protruding bone points. The object of the treatment of recent sprain is first to replace all the parts in their normal position.

This point has been already thoroughly dwelt upon by Ravaton,[1] who says: 'When I am called to a person who has just suffered from articular 'distortion' and before the swelling has appeared, I never fail to cause both articular portions to be drawn asunder by strong hands. If the sprain is in the wrist or ankle joint, I clasp the joint with my two hands, crossing the fingers and pressing strongly in all directions upon the bones in order to place them properly in position, in case they shall have been at all misplaced. I then, if the extensor tendons have escaped from their sheaths and become displaced, as I have often found to be the case, endeavour to raise them with my fingers in order to replace them in their proper position. I then bend and extend the joint, and after that put on the bandage.'

In effecting these manipulations one naturally has recourse to chloroform, in order to remove pain and muscular tension. This restoration to the normal position is very important for those joints which have interarticular cartilages, because the latter are easily displaced by a twist, and then become inter-

[1] Ravaton, *Pratique moderne de Chirurgie*, vol. iv. p. 227.

posed between the articular surfaces, a condition which the English call by the name of 'internal derangement.'[1] At the same time we must always examine carefully, under chloroform, whether there is any injury to the bones, as the existence of such injury would greatly modify the kind of treatment to be employed. These manipulations, which have the object of bringing back the displaced parts into their proper position, may be considered the beginning of massage.

The second task of massage is the removal of the muscular spasm which the sprain has set up. Every over-stretched muscle assumes a condition of permanent tension, which is not only painful in itself but also causes pain by the strong pressing together of the articular surfaces. These painful muscular tensions yield to the influence of soft rubbings in the same way that lumbago does. The ankle is the joint which is most frequently exposed to sprain on account of its position and function. Massage of this joint should begin with light centripetal strokings, at first with the finger-tips, then with the palms of both hands, beginning at the toes and extending so far up the leg as the painful tension reaches. Gradually as the tenderness diminishes the friction should become firmer and stronger. If the tension yields so far that the joint begins to be movable, a few slight movements of flexion and extension should be added, and finally the foot is to be enveloped in a flannel bandage. After the second or third operation the movements in the foot joint generally begin to be tolerably free and painless, and then the patient may be permitted to make a few steps. If no pain arises from this we allow the use of the foot to be increased gradually, whilst watching that no new inflammatory swelling arises, until finally the normal use of the joint returns. In a similar manner we proceed with all the other joints of the body.

With regard to the third series of conditions which are seldom absent in serious sprains, namely, the rupture of ligaments and even the separation of small portions of bone, massage is naturally powerless. It can certainly spread the extravasation

[1] These cases of displacement of the fibro-cartilages of the knee joint require a special method of manipulation, first described by Hey of Leeds, A.D. 1790. See *The Surgery of Deformities*, p. 108.—N. S.

of blood over a larger surface and thus hasten its absorption, but it is not able to effect the healing of the ruptured tissues. Time and repose in a good apparatus or bandage are here necessary and indeed are indispensable. In fact it would be a mistake to imagine that we are able to cure quickly every sprain by massage and movements. If these serious complications exist such measures would rather delay than hasten the cure, because by movement such an injury may eventually even pass into a condition of chronic articular inflammation, which would be the worst and most dangerous consequence to be feared. By means of an intelligent use of this remedy, however, the movement cure is always able to procure a quicker restoration of the power of use than is a continuous position of repose.

The *second* important use of massage and movement is in the breaking down of adhesions which have formed in the course of inflammation, and the smoothing off of rough surfaces. In this respect a few remarks must be made upon stiffness of the joints after inflammation. As we cannot carry out any movements during the course of inflammation itself, but are obliged to allow the joint to remain in one particular position, we almost always see that after the resolution of the inflammation the mobility of the joint is very considerably diminished, partly in consequence of thickening of the articular capsule and the ligaments surrounding it, and partly in consequence of coalescences which have developed between the articular surfaces. To remove these coalescences, to smooth the rough cartilaginous surfaces, and to restore elasticity to the capsule and ligaments, is one of the most difficult tasks of surgery. Its difficulty consists in this, that one must persist with energy and yet at the same time with the most careful increase of strength, for too rapid operations may very easily cause a new outbreak of the inflammation which again necessitates fixation of the joint for a long time. Warm and even hot baths, either of artificially heated water or the natural thermal springs, with the addition of hot spray and steam douches, assist in procuring mobility of the joint. Whilst these douches act upon the affected joint, the masseur manipulates it, by rubbing, pressing, kneading, and, when the time has come

for it, also by passive movements. He proceeds slowly until mobility gradually becomes freer, and more active movements are possible, to which complicated actions may afterwards be added. With respect to the ultimate cure, much depends upon the experience, the natural dexterity, the persistence and even the strength of the masseur. Precise rules cannot be given. In dexterous hands, joints often recover almost complete mobility when one could hardly have considered it possible, whereas other joints resist all endeavours, principally because they are too irritable, so that relapses of the inflammation perpetually recur, compelling abandonment of the treatment.

That which is true of adhesions of the articular surfaces is true also of adhesions of the tendons and their sheaths, either to one another or to the bone surfaces over which they pass. The most frequent cause of such adhesions of the tendons is acute abscess of the fore-arm. Partly because phlegmon most frequently happens in this situation, in consequence of wounds of the fingers, which are so exposed to infectious matters, and partly because in no other part of the body are there so many tendons together as at the inner surface of the fore-arm, interference with the mobility of these tendons hinders the use of the fingers, and thus injures in the most serious manner the working powers of the person affected. Under the influence of Lister's dressing, which so much diminishes suppuration and thus limits the contraction and coalescence of the inflamed parts, these conditions become much more favourable; but even with the best treatment a severe phlegmon of the forearm leaves serious hindrances to movement, which require a long and careful gymnastic treatment for their removal. By means of rubbing, pressing, kneading, and passive movements, with the help of warm baths, a dexterous manipulator will be able to produce favourable results in the course of time, by loosening the adhesions and smoothing the opposing surfaces.

We succeed better in stiffness of joints and tendons, the sequelæ of fractures occurring in the neighbourhood of the joints. If only the fracture has been cured without much displacement, which is indeed a *sine quâ non* condition, then, as a rule, mobility can be pretty quickly re-established.

The great advantage which these cases have over articular

inflammations is this, that no special or at least no infectious inflammation has preceded them, and therefore no relapse is to be feared. It is here much more a question of disturbances of movement from long repose of the parts, or the proliferation of the fracture callus into the articular cavity, as well as coalescences of the callus with muscles and tendons. All these difficulties are comparatively easily removed, because even the external fracture callus undergoes in the course of time a very decided retrogression, and thus the hindrances which originally opposed extended movement partially cease of their own accord. We shall always do well, even in these cases, to have recourse as soon as possible to treatment by movement and massage, and not to expect too much from spontaneous abatement of the impediments. The more important is the restoration of complete mobility in the affected joint the more carefully and the more perseveringly must we act upon the latter.

Special attention is required to the adhesions which are left in female pelvic organs after *peri-* or *para-metritis*, as these, by dragging and displacing the uterus, not only often produce sterility, but also, by causing hysterical attacks, may most seriously deteriorate the general health. Removal of these adhesions, and the release of the uterus from its fixed position is certainly a very difficult task, because any energetic treatment may so easily cause a return of the inflammation. Here too we commence with warm baths, compresses, and vaginal douches.

Direct massage of the uterus, as Thure Brandt (76), of Sweden, has carried out pretty frequently, according to his reports, appears to me, upon the above grounds, to deserve great attention. Brandt proceeds so energetically as to employ two assistants for this massage. The one, by means of his fingers introduced into the vagina, raises the uterus against the abdominal wall; the other grasps the uterus from above through the parietes, so that he holds it between the thumb and the next two fingers. The operation is by rubbing, traction, pressing, &c., performed alternately by these assistants for the purpose of loosening the adhesions. I certainly believe that it is sometimes possible by such means to restore the

mobility of the uterus, but the measure is a serious one and therefore dangerous. At least it should suffice for one individual to conduct the massage, by raising the uterus with his fingers in the vagina and effecting the rubbing with his other hand above the symphysis.[1]

It is, however, still safer to avoid any direct attack upon the uterus, and by systematic movements, principally of the lower extremities and the lumbar portion of the vertebral column, to act upon the adhesions in the true pelvis. The quickening of the circulation of the blood and lymph, which these movements undoubtedly effect, as well as the alterations in position of the abdominal and pelvic viscera which are produced, may well tend to release these organs; and although they demand a longer time for this than does direct interference in the vagina, they are further not attended with the dangers which are inseparable from the latter, and may be accomplished more easily and in a less unpleasant manner.

We must now describe the operation employed to render an old incarcerated irreducible hernia again reducible. Besides a long-continued recumbency of the patient, low diet and thorough emptying of the intestines, the hernia is subjected to from $\frac{1}{2}$ to 1 hour's massage daily. By rubbing, pressing, and kneading, in order to loosen as much as possible the attachments which exist between the mesentery and hernial sac, and by pressing the loosened and now movable parts into the abdominal cavity, it is possible gradually to diminish the hernia. The result thus produced is maintained by a firm, hollow, leathern truss applied over the hernia, and fastened to a leathern girdle sufficiently tight.

The satisfactory result which may be obtained by patience and perseverance in this respect is shown by the case of Thiry,[2] who succeeded in four months in returning completely to the abdominal cavity a very large inguinal hernia, of twenty years'

[1] It has been stated that Brandt is 'the first gymnast who has been engaged in a large and successful gynæcological practice'!—N. S.

[2] Thiry, 'Hernie inguinale constituée par la plus grande partie de la masse intestinale. Taxis et compression progressifs, périodiquement répétés pendant quatre mois. Réduction et guérison,' *Bull. de l'Académie de Méd. Belgique*, 1881, No. 6.

duration, which hung down as low as the knees, in a man of forty-two years of age.

Adhesions of the pleura are frequently loosened by the rubbing together of the two membranes in respiration. If many attacks of pleurisy have followed one another, then certainly the adhesions often acquire such toughness and firmness that their removal is impossible. If we wish to act therapeutically after the subsidence of pleurisy, so that the adhesions which have probably occurred shall be removed more quickly than would happen in the course of ordinary breathing, we advise regulated deep breathing in a systematic manner, or gymnastic movements in which especially the arms are held high, particularly suspension, as in this position, from the great tension of the thoracic muscles, a considerable raising of the ribs takes place, as happens in a very deep inspiration. These movements, however, must be performed with great caution in order not to produce a return of inflammation from dragging upon the lungs.

After the fortunate resolution of a peri-typhlitis, the adhesions caused by the inflammation in the course of time loosen of themselves. If the loosening is delayed and inconveniences occur which may be referred to a dragging upon the intestines from such adhesions, one may endeavour, by very cautious rubbing, to effect their more rapid loosening.

The adhesions which undoubtedly occur at first between the surfaces of the testicle and tunica vaginalis, after the operation for hydrocele, whether it be by the injection of tincture of iodine, or by incision, loosen themselves in the course of time, probably from the movable position of the testicle, generally so completely that a new serous cavity forms which may a second time become a hydrocele by collection of fluid.

Even for heart-disease Dr. G. Zander[1] recommends slight gymnastics. It is surprising what a beneficial influence, regular, slight but varied muscular exercises exert upon diseases of the heart. Some conditions of disease, if they are not too far advanced, may be quite overcome, others may be stopped in their

[1] G. Zander, *Die Zander'sche Gymnastik und das medicinisch-heilgymnastische Institut zu Stockholm.* Stockholm, 1879

development, and all are alleviated as regards their symptoms. Zander has taken patients under treatment in the last stage of valvular disease, and observes that, although they knew that a cure could not be expected, they gladly availed themselves of the gymnasium as long as strength permitted, on account of the alleviation which the treatment produced. I must here add to what I have said on this point in the introduction, that I have since heard that a gymnastic institution fitted up with Zander's machines has been established in London.

Chronic disease of the lungs in the form of incompletely resolved pneumonia, chronic catarrh, and even commencing tubercular phthisis, are also often benefited by gymnastic treatment. We may to some extent consider as such the inhalation of compressed or rarefied air, as the patient is thereby compelled, by means of tension of his respiratory muscles, to exercise himself by taking regular, prolonged, and deep inspirations. Walking on hilly roads and even a moderate amount of climbing mountains, which takes an important place in Brehmer's method of treatment of consumption, must be regarded as a gymnastic process, inducing deeper respirations by increased muscular activity, and thus procuring increased expansion and aëration of the lungs. But even still more energetic muscular activity has proved strikingly beneficial to people who were already suffering from very serious symptoms of phthisis. Certainly we must not select the horizontal and parallel bars, as these exercises cause too much strain at the moment of performance, and then require each time a long pause for rest.

On the other hand, rowing is a very good gymnastic exercise for such patients, when pursued in a systematic manner in light and well-built boats of various kinds.

A considerable improvement was made in rowing in 1872 by the sliding seat which was in that year first introduced into England. The rower sits upon a small seat, provided with two slight indentations for the two tuber ischii, which glides backwards and forwards. The feet are placed at the bottom of the boat in two slipper-shaped leather straps fixed upon an oblique footboard. The feet thus form the fixed point. Then the oar is grasped and the upper part of the body is bent forwards, whilst the legs by separation of the knees draw the whole body forwards with the sliding seat towards the feet which

remain firm in the foot-straps, so that the body is bent between the opened knees. At the same time the arms are stretched straight forwards in order to bring the inner ends of the oars as far in that direction as possible. At the moment at which this point is reached by the united action of the arms, body, and legs, the blades take the water. The power which the hands have been obliged to exert upon the short inner lever of the oar in order to keep the longer lever out of the water ceases suddenly, the blade is dipped beneath the surface, and then the pull begins at once with full force. In this action the upper part of the body and the legs again act simultaneously. While, for instance, the knees, bent at an angle of 60°, are gradually stretched and thus push the seat backwards, the upper part of the body performs the second part of the swinging motion, the movement backwards out of the perpendicular. Finally, the arms, which have hitherto been used merely mechanically, come into action as they draw the handle of the oar towards the chest by their adduction. It is at this last part of the movement that it is most necessary for the rower to preserve the above-described extended position of his head and trunk. At the moment in which the oar-handle touches the chest it is at once depressed, and by that means the blade raised from the water. All these movements follow one another in regular order, without hurry, but also without any pause, so that not only the upper part of the body, but also the arms and legs, are used in uniform succession. No single movement is at all a strenuous one, but the sum of the whole, when pursued for hours together without a pause, supplies a very considerable amount of work accomplished without any separate movement occurring which could make too great a demand upon the voluntary muscles, or upon the heart and lungs.

The above description of rowing as a sport is taken from the rules of the Berlin Rowing Club, as published by Dr. Mitan, in his dissertation 'Das Rudern, eine heilgymnastische Uebung,' Berlin, 1882. I have personally inspected the proceedings of this club, and it appears to me that rowing, conducted in this systematic and scientific manner, is a gymnastic exercise which, by the regularity of its action, is in the highest degree suited for the treatment of invalids who require their muscular system as well as the functions of their respiratory and circulating organs strengthened. Of course one cannot permit an invalid to take part in races; these must be for the strongest and most practised rowers, who are able to command

a superabundance of muscular power; but the tranquil and yet continuous labour of the whole body in a boat for two rowers, or in a 'sculler,' *i.e.* a boat rowed by one person with two short oars, are movements which may be considered beneficial even in pulmonary disease. As advantages we must consider the moist air perfectly free from dust, and the change of scenery. In illustration, two gentlemen who suffered from considerable phthisic symptoms completely re-established their strength and health here in Berlin in the course of six months by means of this systematic rowing upon the Oberspree, having previously visited Italy and the mountain-cure residences of Switzerland without much result.

We must also regard as a remedial gymnastic measure of a passive character, the performance of artificial respiration in apparent death from drowning, whether by Marshall Hall's method—namely, the alternate lateral and dorsal positions, with powerful pressure on both sides upon the lower portion of the chest—or by Sylvester's method, in which the expansion of the thorax is obtained by elevation of the arms (over the head of the patient), and contraction by bending them back again.

Chronic constipation, in consequence of torpidity of the intestinal canal, also often indicates a necessity for gymnastic treatment. In these cases likewise the active muscular powers of the patient should be in the first place exerted by walking, rowing, and similar movements. If, on the other hand, the patient is already old and suffering from other infirmities, one cannot advise him to take any more exercise than driving in a not too easy carriage, and in any case walking or slight chamber gymnastics, and in these cases massage of the lower part of the body proves very advantageous. Every masseur naturally develops in the course of his practice a method according to which he conducts the rubbing and kneading of the lower part of the body.

An apparently very dexterous and practised French masseur, M. Laisné (72), gives the following description of the method:—The patient reposes in bed with the upper part of the body rather high, the legs somewhat separated. The masseur then places his hands on both sides of the abdomen and tells the patient to allow his muscles to relax completely, so that the external pressure shall

reach the intestines uninfluenced by resistance. He then performs a tolerably powerful double, but not forcible, rubbing with both hands in an opposite manner, *i.e.* so that one hand ascends while the other descends. Thus the thenar and hypothenar eminences exercise the principal pressure, without passing beyond the position of the transverse colon superiorly, or the ileum inferiorly. This first operation should last from thirty to forty seconds; then the masseur places his right hand upon the region of the jejunum, pressing and rubbing over the intestines gently in an undulating manner. When he has reached the cæcum, he should follow the course of the ascending, transverse, and finally, the descending colon with the whole surface of the hand, and repeat these manipulations two or three times. If no result is attained by this manipulation he should wait till the next day, and then repeat the performance. M. Laisné declares that he has often removed recent constipations in this way at the first operation, and feels himself justified in considering this method, although certainly not infallible, yet still in general a very successful one.

Also for *catarrhal icterus*, movement and massage may be recommended as a means of cure. Here also active movement of the patient himself stands in the first place. However difficult it has become to him, owing to the relaxation and weariness which affects the whole body at the time of the biliary stoppage, he must nevertheless rouse himself and take exercise, either on foot, in a carriage, or, better, on horseback. The circulation of the blood is thus quickened, the hindrance to the discharge of the bile gradually overcome, and as soon as the bile enters the intestine the other symptoms rapidly disappear. I have in former years experienced the effectiveness of this method in my own person when suffering from a tolerably severe catarrhal jaundice, and since then I have succeeded in producing a similar good result in the case of other patients. Those who, from great weakness or old age, are not able to avail themselves of these kinds of movement, may find a substitute in massage of the region of the liver, which, however, should not be too energetically carried out.

Even in severe ileus, symptoms caused by a mechanical hindrance to the discharge of the intestinal contents have been happily removed by massage, as in the cases which M. Buch (80) details.

In the first of these cases, a boy six years old, after the unsuccessful use of clysters and laxatives, was relieved by massage from a serious invagination of the intestines, which had already caused very alarming symptoms. In the second case, a woman fifty years of age, with relaxed abdominal walls, was cured by means of external pressure, a great number of hardened fæcal masses being removed from the lower part of the ileum into the cæcum, and there softened and discharged by laxatives. In the third, a woman thirty-six years old was relieved from the acute symptoms of obstruction after a sausage-shaped movable swelling situated to the left of the umbilicus, which was supposed to be an invagination, had been greatly diminished by systematic *stroking* movements.

Although this operation is of course not always attended with such complete success as in the cases just mentioned, we shall nevertheless always do well to attempt it before resorting to the final means of abdominal section and the attempt of removal of the obstruction under the guidance of the eye.

Whether it is possible to interrupt an attack of *nervous asthma* by any sort of gymnastics or massages, I do not know, but I consider it probable that the inclination to asthmatic attacks may be diminished by a mild, long-continued gymnastic treatment especially directed to the respiratory movements of the thorax. Here, too, one should, at least in youth, particularly recommend systematic rowing in moderation.

For severe *pains in the head* and *migraines* massage is recommended, not in the form of a powerful rubbing and kneading, but by means of extremely gentle strokings of the patient's face with the finger-tips and the palm of the masseur's hand. It cannot be doubted that by dexterous manipulations a hypnotic condition may be produced, during which the pains disappear. Very important considerations, however, attend the therapeutic application of this fact, especially with women inclined to hysteria. At any rate, hypnotism, which has been known ever since Mesmer's time, a hundred years ago, and has often been tried with respect to its therapeutic capabilities, has hitherto afforded no permanent results ; on the contrary, has often, by means of an over-excitement of the whole nervous system, injured the patients who have been treated by it.

Neuralgia may be diminished and even completely removed by a strong pressure upon the places of exit of the painful nerves from foramina and clefts of the bones. Powerful friction of the affected part, especially in the case of that commonest form of neuralgia, of the fifth nerve, has often, when the affected part of the face has been rubbed until it is extremely red or even the skin broken, given relief to those affected with this terrible evil. The effect is, however, very transitory, and permanent cures of neuralgia cannot be attained by either gymnastics or massage, unless it is a case of hypochondriacal or hysterical neuralgia, the removal of which by an energetic movement cure may not be impossible.

There is a great field for the employment of systematic gymnastics in the irregular muscular enervations, such as scrivener's palsy, stuttering, and chorea.

For scrivener's palsy, the pathology of which we cannot here discuss, Wolff, teacher of writing in Frankfort-on-the-Maine, has recently invented a treatment by massage and gymnastics, chiefly localised to isolated muscles, by which he has attained a large number of successes, which have been attested by the principal medical authorities of Germany. An account of this procedure was written by Th. Schott (92), though such a description is not of much use, as the various movements and manipulations cannot be sufficiently or graphically represented for anyone to be able to apply them himself.[1] To overcome this drawback, and to reduce the treatment of scrivener's palsy to a method which will be accessible to every medical man, Professor v. Nussbaum published a small brochure under the title of 'Einfache und erfolgreiche Behandlung des Schreibekampfes: eine vorläufige Mittheilung. München, 1882.

The idea which underlies Nussbaum's method is as follows.[2] That as writing is almost exclusively performed by the action of the flexors and adductors of the fingers, and these are placed in a condition of much increased excitability owing to constant exercise, so that they

[1] *See* a letter from Dr. Kingston Fowler in *British Medical Journal*, Oct. 28, 1882. Also a paper by Dr. De Watteville, *Lancet*, May 2, 1885.—N. S.

[2] See *British Medical Journal*, Oct. 14, 1882; also *American Journal of Medical Sciences*, April, 1885. Paper by Dr. R. P. Robins.—N. S.

spasmodically contract upon grasping the pen, it might be hoped that a method of writing by which, on the contrary, the extensors and abductors of the fingers should be used might prove curative. For this purpose, Nussbaum constructed an oval cradle made of guttapercha, which bears the pen-holder fixed to its upper surface with a screw. This cradle is somewhat broader than the hand, and therefore when it is pushed up over the fingers it must be held by means of the latter being outstretched. The writing will now be accomplished by a movement of the whole hand. As soon as the patient ceases to use his abductors, the cradle becomes loose from the fingers and the writing ceases. The patient is therefore obliged, instead of using exclusively his flexors and adductors, to employ the extensors and abductors. By means of this use of the antagonistically working muscles many patients were able, with the help of the cradle, to continue writing who previously had been hardly able to form a single letter. Nussbaum hopes to secure a further success, which will certainly take a much longer time to attain, viz. that when a patient has written for some time with the help of the cradle, and has thus employed his abductors and extensors, while the flexors and adductors have reposed, he may return to the usual way of holding the pen without being troubled with the spasm, as in time the balance between the previously deranged muscular antagonism will be re-established. If this hope is fulfilled, Nussbaum's method will be one of the most brilliant therapeutic discoveries in neuro-pathology, and, as is so often the case in great discoveries, will strike us by its simplicity. But even if this hope is not fulfilled, Nussbaum's cradle will remain a great acquisition in the treatment of this affection, hitherto so difficult.

Stuttering is an important indication for systematic treatment. I cannot here enter closely into the very complicated process which lies at the foundation of that disturbance in speech which we designate by the name of stuttering. For that purpose I refer the reader to Kussmaul's work 'Die Störungen der Sprache,'[1] and also to the short, but instructive *résumé* which the Obermedicinalrath, Dr. Kelp, has published under the title 'Ueber das Stottern und dessen Behandlung in dem Katenkamp'schen Institut,' published in the 'Berliner klinischen Wochenschrift, 1879, Nos. 18 and 19.

[1] Kussmaul v. Ziemssen's *Handb. d. spec. Pathologie u. Therapie*, xii. Band. Anhang, 2te Auflage. Leipzig, F. C. W. Vogel, 1881.

Here it will suffice to point out that there are two distinct faults of speaking which we call respectively 'stammering' and 'stuttering.' Stammering is a permanent fault in articulation, extending chiefly to the formation of the consonants, which is always and under all circumstances defective or impracticable. Formation of the vowels may be only so far defective as it is produced by articulation, *i.e.* lips and tongue do not properly articulate the sound. Respiration and voice do not suffer, there is no psychic embarrassment. This derangement probably depends upon a deficient formation of the muscular organs of articulation, the tongue, velum palati, and lips, and is not to be successfully influenced by treatment. Stuttering, on the other hand, is a momentary incapability of pronouncing certain vowels or consonants, or to connect them together, consequently a momentary failure of articulation or phonation. The sufferer is more or less psychically embarrassed, and when completely unembarrassed, as in singing and declaiming, is able to pronounce properly, or only to allow his failure of speech to appear to a very slight extent. With stutterers respiration and phonation are momentarily or for a short time completely interrupted. According to the degree of the affection, the respiratory muscles, the larynx, the tongue, the lips as well as the whole face, are convulsed. Careful examination of stutterers proves that the fault is caused either by a convulsive contraction of the articulatory organs, the lips and the tongue, or by a convulsive contraction of the phonetic organs of the glottis, or finally by a spasmodic irregularity in the respiratory movements. Stuttering thus appears to be a fault in the mental function, a psychosis in a wider sense, expressing itself in defective respiration, articulation, or phonation. The brain is, much against its will and consciousness, unable to regulate the innervation of the part affected. An abnormality exists in the nerves of the respiratory, articulatory, and phonetic organs, which either appears as spasm or as irradiation and irregular participation of other muscular groups.

Although psychic embarrassment must be regarded as the root of the evil, yet there may exist also an hereditary weakness of the nerve-centres for respiration and voice situated in the medulla oblongata, and these centres, impaired in early youth by some psychic impression, have not recovered, and subsequently may be influenced by the mere excitement of the will to give rise to incoordinate movements; hence stuttering is to be regarded as a psychoneurosis. This either appears at first with the child's earliest effort at speaking, or develops itself under the influence of a violent psychic impression in childhood, but only seldom appears after the tenth year. It is

more generally males who are affected with this; so that, according to Katenkamp, the average proportion of males to females affected is as ten to one.

The only successful treatment of stuttering consists in a carefully regulated exercise of definite muscular groups in order to attain a properly regulated associated action of them, and by this means to remove the fixed idea of incapacity caused by the psychic embarrassment. According to the three different groups of movements by which speech is produced—the movements of respiration by means of the muscles of the thorax, the movements of phonation by the muscles of the larynx, and the movements of articulation by the muscles of the mouth—it is the regulation of these three muscular groups which must be obtained by means of a systematic, well-considered gymnastic training.

This idea was first practically carried into effect by Madame Leigh in New York, in the year 1828, whose chief attention was directed to the gymnastics of the tongue. Malebouche paid attention to the movements of the lips as well, and Arnott added the treatment of the muscles of the larynx. Colombat de l'Isère, founder of the orthopædic institute in Paris, established the rhythm, the measured breathing, and used for that purpose the methonome, a small instrument made of silver and ivory, which is pushed under the tongue and fastened to the incisor teeth in order to keep the tongue drawn back, and thus to accustom the stutterer to measured speech. Vocal gymnastics are performed by pronouncing aloud first those words which begin with simple vowels, then those with lip sounds, and finally those with tongue sounds. Klenke laid special value upon facilitating the harmony between the brain and respiratory system, and again restoring that between the latter and the organs of articulation, so that the brain might be strengthened as regards the exercise of the will upon the organs of respiration, the organs of speech being trained to perform certain difficult movements of articulation and phonation. Dr. Katenkamp, originally a teacher, established in the year 1845 an institution for stutterers in Delmenhorst in the Grand Duchy of Oldenburg. His method, to the exclusion of all external mechanical aids, only dealt with the psycho-neuroses as a whole expressed in stuttering. It is not, however, an aggregate of foreign elements, but a complete organic development, the parts of which all subserve the main purpose.

Another disturbance of coordination which may be favourably influenced by gymnastic treatment is chorea.

In the years 1847 to 1857 very searching investigations on this subject were made in Paris. In the year 1847, for the first time as an experiment, a gymnastic course was carried out in the Hôpital des Enfants malades, in which scrofulous children were principally received. The results which were attained by this inquiry were strikingly favourable, and the committee of physicians of this hospital informed the Conseil général des hôpitaux et hospices civiles of Paris of the matter in detail. To this information Dr. Bonneau added the notice, that gymnastic treatment had had good results in other diseases besides scrofula, and especially in chorea. In the year 1849 the medical committee published a second report, in which it petitioned for the permanent establishment of gymnastics in the children's hospital, and dwelt upon the favourable results which had already been obtained by them upon chorea, whereupon the establishment of the gymnastic hall was definitely determined upon. A mémoire upon chorea, written by Dr. Sée, in which he gave the first place to gymnastic treatment of this disease, was honoured by the Académie des Sciences. In the year 1854 Dr. Blache handed in a report to the Académie de Médecine of the results attained by the gymnastic treatment of chorea, of which Bouvier in the year 1855 reported very favourably. Then followed several reports in the journals of the cases of chorea favourably treated by gymnastics until the year 1868. How these matters have since progressed in France with respect to the gymnastic treatment of chorea I do not know. In Germany since the year 1850 this treatment has been talked of, but the method has attracted no great attention, and has for some time been entirely forgotten.

The manner and degree in which gymnastic treatment of chorea is conducted is as follows. At first when the muscular contractions are so strong that the limbs and body are thrown in all directions by irregular movements, the patient is laid upon a mattress, and held as steadily as possible by three or four assistants for from ten to fifteen minutes. Then the masseur begins with the whole hand to stroke lightly the upper and lower extremities, as well as the chest, with movements gradually becoming stronger. Then the body is laid in the prone position and the same strokes are repeated upon the back, and especially on the neck, and on the large muscular

masses on both sides of the vertebral column. An operation of this kind lasts about an hour, and is repeated in three or four days. After every operation the irregular muscular contractions ought to become slighter, and the patient should in favourable cases feel better. Sleep, which at the time of the most violent muscular cramps had completely ceased, returns gradually, and speech too begins to be restored. During the following days slight strokings and rubbings are continued, and in addition, the masseur begins to produce regular and rhythmically arranged passive movements. Regular movements of the extremities in the three principal joints are especially performed. In these movements there is generally a considerable tension of the antagonists to be overcome; gradually, however, the tensions relax, and the child is soon able to assist the movements performed upon it by active muscular contractions. The pains too, which were at first caused by pressure on, or stretching of, the muscles, diminish after several operations. After these passive gymnastics have been continued for from eight to ten days, the will gains so much mastery over the muscles as to enable the child to eat without assistance and to walk some steps although with much staggering. Now he is taken into the gymnasium and instructed with other children. The movements which are conducted here are the simplest physiological movements of the limbs and body, which keep the attention and the will active. A great number of movements are regulated exercises to which the teacher as well as the scholars sing songs in measured time which agrees with the movements. The rhythm and imitation favour the mastery of the will over the muscles.

Those children whose improvement has already advanced considerably are practised singly under the direction of the teacher in some easy frame exercises. Such are exercises of suspension, in which the child endeavours so far to control the involuntary contractions as not to loose his hold on the bar which he has grasped. At first assistance is necessary for these exercises. As soon as fatigue supervenes the exercises are interrupted. Strict order and discipline must prevail in the gymnasium, and the final success is hastened when the teacher is able to exert a strong moral influence over the

children. Under the influence of the exercises the character of the children improves; they become more cheerful and docile, the appetite, and also muscular power increases, and the thin and suffering countenance gains plumpness and colour. After from ten to twelve days there is generally a standstill in the improvement, over which the children must be helped by kind persuasions. Soon, however, the improvement again continues, and a rapid and radical cure follows. Dr. Blache asserts that at the time of his report, of all the children treated up to that time in this manner, not one had suffered a relapse ; differing from the statement of Sydenham, that chorea generally reappears in the autumn of the next year.

As to the comparative merits of the gymnastic treatment of chorea, Dr. Blache asserts that it is as efficacious, nay, even more so, than the plan which has been hitherto considered the most valuable for this disease, viz. warm sulphur baths. Some cases have proved extremely obstinate against both methods. Of 135 affected children, who were treated with sulphur baths, 18 remained uncured ; of 108 treated by gymnastics, only 8 remained uncured. But gymnastic treatment has also this advantage, that it may be carried out in all cases ; whilst warm baths, with the large addition of sulphide of potassium as is necessary for this purpose, often cannot be endured. At first also increased restlessness often follows the warm sulphur baths, whilst gymnastics are soothing from the commencement. It is sometimes advantageous to combine both methods ; nevertheless, in the majority of cases the effect is not increased. Good nourishment and tonic medicines favour success, which is on the other hand retarded by all that is weakening, and by narcotic agents. With the cessation of the irregular muscular contractions disappears also the anæmic condition which seems to be the foundation upon which the chorea develops ; the palpitation of the heart and the vascular murmurs also cease. The cure of chorea by gymnastics appears to be more permanent than that obtained by any other means, even by sulphur baths.

The report which Bouvier presented to the Académie de Médecine upon the mémoire by Dr. Blache was favourable to gymnastic treatment of chorea, and closes thus :—

'En résumé, nous disons, en modifiant quelque peu les termes des conclusions dernières de M. Blache, que, dans la plupart des cas, la gymnastique ne le cède en efficacité à aucun des autres modes de traitement de la chorée, et qu'elle n'a point les inconvénients attachés à plusieurs d'entre eux.'

Besides chorea, gymnastic treatment is applied to other severe nervous and even mental diseases.[1] The hospitals of Bicêtre and La Salpêtrière had, in the year 1850, their gymnasiums, and probably still have them, in which young epileptics and idiots performed easy, free exercises, regulated by well-marked time under the direction of a teacher. Moreover with reference to the results obtained in these cases, Bouvier speaks very favourably. The epileptic fits became more rare, and with some patients even ceased for so long a period that the cure might reasonably be hoped to be permanent.

Those who interest themselves specially in this question will find all the particulars referring to it in Laisné's work 'Du Massage, des frictions et manipulations appliqués à la guérison de quelques maladies,' Paris, 1868. M. Laisné is, moreover, the masseur who introduced and elaborated this method for the treatment of nervous diseases, and under whose direction most of the favourable results mentioned above have been attained.

Also in the Charité of this city (Berlin) some experiments were made in the beginning of this century in treating mental disorders by means of gymnastics; only the gymnastics were of a peculiar kind. The patients, both men and women, were placed in military uniform, and then exercised in a regimental manner by a subordinate officer; or else a number of them were placed together upon large revolving discs, with their feet to the centre and their heads to the periphery fastened in this position, and then the wheel was rotated with tolerable rapidity. It was hoped that by this means the circulation in the brain might be favourably influenced. It appears, however, that the result was not favourable, as this plan has neither been continued nor imitated.

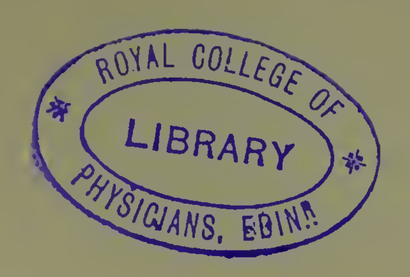
Severe cases of hysteria with paralysis have sometimes been cured in a comparatively short time by means of massage and slight gymnastics; but that is certainly not saying much,

[1] An interesting short paper by Dr. Spender, of Bath, upon Shampooing and Gymnastic Exercises in the treatment of epilepsy is published in the *British Medical Journal*, May 2, 1885.—N. S.

because of the changeable nature of this disease. However, when all else has been tried in vain, this treatment may be had recourse to.

Muscular paralysis and paresis, especially such as remain after infantile paralysis, may be sometimes, as it appears, favourably treated by massage in addition to electrical treatment.

With the above cases, so far as my observation extends, the medical uses of gymnastics, in the widest sense of the word, are pretty well exhausted. Without praising this treatment too enthusiastically, I believe that it may be adopted in many cases with the happiest results, and that it has many undoubted advantages over pharmaceutical remedies. Medical men themselves will certainly only in very exceptional cases direct the practical carrying out of the manipulations, and indeed it is not to be desired that they should do otherwise. It therefore becomes necessary to select from the ranks of the attendants upon the sick such persons as are distinguished by strength, dexterity, and endurance, and—which is not to be underrated—who possess a certain amount of intelligence and cultivation, so that they may be educated under the superintendence of the physician, for the severe and uncommonly fatiguing, nay, even detrimental occupation of a masseur. There is, for instance, not only the fatigue to be considered, which is the natural result of the performance of the movements for consecutive long periods, but also the nervous excitement which is produced by stimulation of the peripheral nerves on the palm of the hand and the fingers and conveyed to the nervous centres. If the individual, medical or otherwise, possesses the necessary qualities for the performance of massage in a high degree, he may in many cases obtain results which may be considered as really astonishing.



HYDROTHERAPEUTICS,

BY

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INTRODUCTION.

The application of hot and cold water as a curative measure is not an invention of modern times. Notwithstanding that the ancients and, as will be found in the following representation of the history of hydrotherapeutics, nearly every epoch as far as our knowledge extends used water for purposes of cure, our scientific hydrotherapeusis is one of the youngest branches of the tree of scholastic knowledge, or—we may as well speak out at once—it is yet in many cases (although perhaps only from ignorance) treated as a parasite upon that tree.

By right the physical direction in the exact medical sciences should be also the standard for therapeutics. Were this the case, then hydrotherapeutics would take one of the leading parts; for if we only cursorily consider what great problems in the organic economy it is the lot of heat to solve, and how all nutritive processes depend upon the temperature, an alteration of which alters the nutritive conditions also, it must already therefrom become evident to us that an agent which is capable of controlling the temperature *with physical exactitude* must be reckoned among the most prominent therapeutical resources.

Although physiology has made itself fairly well acquainted with the influence of water as a vehicle of temperature, clinical study has hardly made even miserable and one-sided attempts to make itself acquainted with the forms of application and *modus operandi* of this most potent agent.

Though the statistics of results achieved by the method of water-cure in the most varied affections number already *hundreds of thousands*, the school has hardly derived any benefit therefrom except in the treatment of febrile diseases. Of reasons

wherefore the school has behaved passively—aye, even negatively—towards this healing agent there are not a great number.

In the first place the so-called 'water doctors' must themselves be held responsible for this; their immoderate excesses, the endeavour, combined with the question of their ephemeral existence, to represent hydropathy as being in direct antagonism to the principles of scientific medicine, drove physicians in terror from this domain. The ignorance of the method on the part of the physicians, the simplicity of the means, the inconvenience of its application and variation from established pharmaceutical technique, later on nihilism, and finally the deficient knowledge of completed physiological researches, may be looked upon as further reasons why the matter was allowed to become well-nigh clinically obsolete and to remain so.

The results of the antipyretic hydrotherapeusis of the last decades made the want of investigation into the physiology and method of hydropathy more apparent. I have to thank the soil thus prepared and, for the subject, so fertile at present for the greater part of the universal recognition which my labours and researches upon this domain have met with.

A practical want forces us to the clinical examination of the effects of thermal and mechanical interferences, an examination which hitherto has been denied to not a single drug or agent, be it recommended by authority ever so confidence-inspiring.

If, in spite of this, the officinal school has more than quietly neglected the universal necessity for testing properly executed hydriatic methods, it has made itself guilty of a breach of duty which narrows the range of knowledge and operation of the therapeutist to a much greater degree than is ordinarily imagined. Is it possible that the clinician still overlooks the fact that it has been long experimentally proved that we can influence effectually, through the peripheral sensory nerve-endings, both innervation and sensation, aye, even the functions of the nervous central organs?

Must not the clinician acknowledge that in the same way, as well as by actual refrigeration, heating, and mechanical interference, it is possible to operate very powerfully as an alterative upon the movements of the blood, its distribution and pressure, and upon vascular contraction and dilatation?

Is he possessed of many other operative measures whereby to control with physical accuracy both heat loss and generation, manifold metabolic processes and the watery constituents of the organism, as well as secretion, excretion, and diffusion?

I hope that the following explanations will answer these questions decisively.

Though we may have numerous gaps in the physiological, technical, and empirical parts of hydrotherapeutics to complain of, a well-founded opinion yet exists that, as soon as clinical study shall have mastered the subject, they will soon be filled up. It is by no means my object in representing the present standpoint of hydrotherapeutics, its theoretical basis, its method, and its practical application, to cover over these deficiencies and shortcomings. On the contrary these are to be pointed out and a stimulus given for their removal.

The significance of that which is already well founded scientifically, will be by no means diminished thereby.

And it is not to therapeutics alone that the investigation of thermal and mechanical influences upon the organism will be of importance. Many a vexed question in physiology and in pathological occurrences, many a prognostic and diagnostic doubt, has been, and will be, brought nearer its solution from this direction.

We need only point to the process of heat regulation and the function of the skin, to the origin of fever and estimation of vascular innervation and the power of the heart, &c., to show what new and somewhat astonishing advances have been made in their study by the physiological investigation of the actions of water.

The development and present status of hydrotherapeutics will be represented in four sections in this work. In the *first* section a place will be given to the literature and history of the subject, elaborated by Dr. S. Plohn, of Vienna; the *second* section contains a description of the physiological basis of hydrotherapeutics; the *third* will treat of the method of hydropathy; whilst the *fourth*, finally, will embrace general principles for the therapeutical combination of the various hydriatic curative procedures.

FIRST SECTION.

LITERATURE AND HISTORY OF HYDROTHERAPEUTICS, BY DR. S. PLOHN, OF VIENNA.

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Latinos et Arabes,' &c., Venetiis ap. Juntas, 1553, fol. p. 478.—Caelius Aurelianus: 'De Morbis Acutis et Chronicis,' Amstelod. 1755, 4, lib. i. c. 1; 5, lib. ii. c. 1; 3, lib. iii. c. 1; 2, lib. iv. c. 1; 7, lib. v. c. 4, &c. (passim).—Oribasius: l.c. variis locis.—'Aëtii Tetrabiblos,' ed. Froben. Basil. 1542. I. Sermo III. c. 171, 172; Sermo IV. c. 39: II. Sermo I. c. 41, 168: III. Sermo III. c. 33, &c.—Alexander Trallianus: vid. Haller, 'Artis Medicae Principes,' Lausanne, 1769, t. vi. lib. i. c. 2, 15; lib. vii. c. 6 ('De Siti'); lib. xi. c. 1; lib. xii. c. 3, 4, &c.—'Pauli Aeginetae Opus Divinum,' Basil. 1532, lib. i. c. li.; 'De Balneis, quae exstant,' &c., l.c. p. 487.—'Thesaurus Antiq. Romanorum congestus a G. Graevio.' Lugd. Batav. 1699, tom. xii. c. 20, 'De Thermis Veterum lib. singularis,' p. 306.—Rhazes: 'Haller. Artis Med. Princ.,' l.c. 1, vii. de Variolis, c. 1–5, p. 230; c. 11, p. 258 sq.: lib. x. c. 18, p. 274; c. 49, p. 278: lib. xviii. c. 8, p. 288.—*Opera Medica*, Basil. 1544, lib. iii. p. 59, 'De Re Medica.'—'De Balneis, quae exstant,' &c., p. 321.—Bergius: 'Von dem Nutzen der kalten Bäder,' &c., Marburg, 1793, S. 42.—Lessing: l.c. p. 215.—Avicenna: 'Canon Medicinae.' Venetiis apud Juntas, 1595, lib. i. fen. 2, doctr. 2; lib. ii. fen. 3, doctr. 2, c. 6; lib. iii. fen. 16, tractat. 4.—'Isaaci filii Salomonis Liber de Diaetis universalibus et particularibus,' ed. Posthii, Basil. 1570, 8, p. 562.—Gentilis da Foligno: 'Avicennae Canonum Liber, una cum lucidissima Gentilis Fulgi Expositione.' Venetiis aere ac solerti cura Oet. Scoti, 1520.

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17th Century.

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THE HISTORY OF HYDROTHERAPEUTICS.

I. The Medicinal Application of Water in the Olden Times.

Were we to attempt to represent the continuous development taking place in medical matters in the form of a curve, whose undulations would be the higher the more the existing views of the period withdrew themselves from the field of moderate inference to trespass on the domain of mystery and speculation, we should form a line very complicated and full of hills and dales. With a certain degree of regularity, however, we are able to find the periods at which attention was devoted to the cure of disease by water, and these upon the points of descent of steep waves. As soon as the customary therapeutic methods of procedure had involved themselves in a host of resources, with a sophistry which is quite unintelligible to us in these days, then some man was wont to appear—at one time, perhaps, cloudy in his motives and objects, as it were, unconscious, at another far in advance of his time and its views—who would create a sensation by the mighty actions of water, and then found more or less of a school.

The oldest medical archives handed down to us do not by any means indicate the beginning of medicine. In the Vedas of Sanscrit we already meet with a very rich treasury of physic indeed; some of the different authors display a greater anatomical knowledge than they could have obtained in India, where dissections were strictly prohibited. In the Vedas of Susrotas, which occupy themselves chiefly with dietetics, water is often spoken of as an article of dietetic treatment, and even as an antidote, the number and time of the baths being exactly

regulated; and the minuteness of detail which is therewith given shows the importance which was attached to the subject.

The Persians and Chaldeans left the practice of curing in the hands of the Magi, and the existence of holy wells in the neighbourhood of their temples alone leads us to the presumption that in their practice ablution and baths played no unimportant *rôle*. The Nile was worshipped by the Egyptians, as the Ganges is by the Indians; it was supposed to cause women to bear, as it did the earth, and was a god which strengthened the constitution and brought about cure. On its banks priests built their temples, and the sick who collected there found relief in prayer and bathing. The first hydropathic institutions were of a theurgical nature. Gods, first in order Hermes, presided over these, and their representatives, the priests, kept secret and watched over their chemico-theurgical knowledge in their different orders, enjoying considerable popularity. Grecian medicine, an offshoot of the Egyptian, does not deny its descent in the commencement, but the mysteries in the beautiful temple groves lost much of the gloomy and horrifying under the influence of the elevation of views, and of the altogether superior harmony of development which is usually absent in the theurgical science. Water was in high repute with the Greeks. Homer sings not alone of the bathing Nausikäa and Agenor, for in the Xanthos Hector bathes when wounded and finds recovery, and Theocrite reports of a river-bath of 240 maidens. Hercules was the divine protector of the thermal springs, and on old coins we see him sprayed upon by a stream of water issuing from the mouth of a lion, which can only signify, to him who is conversant with the allegorical diction of the period, the tonic properties of water, which were well known to the ancients. Just as the thermal springs received the sanctity of divinity, inasmuch as temples to Apollo the Healer were erected in their vicinity, so laws clothed with the nimbus of religion ordained that cold baths should be administered, and in Sparta made special provision for children, virgins, and old men. Herodotus reports of the Macedonians that they were so inimical to warm baths that their women were obliged to take cold ones even after confinement. In the midst of groves rich in springs, and in the

vicinity of thermal springs, stood at that time temples dedicated to Asklepios, Keos and Knidos being the most famous of these. They were conducted by priests in the strictest theurgical fashion; no uninitiated person was allowed to approach them without previous preparation by prayer and cleansing; the preparatory initiation of the patient consisted in strict fasting of several days' duration, with baths, sacrifice and prayers. In these we can observe, in mystical surroundings, methods of procedure which remind us very forcibly of the methodical deprivation cures of the cold-water-cure institutions of our own times.

The patient passed the night upon the fleece of the sacrificed animal, and in dreams or in visions, which the priests well understood how to put in scene, the god was to manifest himself and give the infallible advice which should cure the malady. Later on, it became the custom to engrave the patient's name, as well as an account of his disease, and of the means by which he was cured, on tablets of metal; and this collection of 'tabulæ votivæ' afterwards formed the basis of a real system of empirical medicine. In the halls of these temples Hippocrates wandered, and the contents of the votive tablets fired the high genius of the man most powerfully who was destined to become the source of all medical truths for the coming generations (454 B.C.)

His system of pathology was a humoral one; as disease originates in disturbances of the fluids of the body, so is the principle of cure carried out by fluids. Even the physiological actions of water of different temperature were known to him.

He was the first to maintain that cold water warms, whilst warm water cools the body. He was acquainted with shower-baths and shampooing. Warm showers induce sleep; cold water poured over the body is useful in fainting. He treated tetanus with showers, and in affections of the joints (who is not reminded of the opposition which the cold-water treatment of *polyarthritis rheumatica* had to labour against up to the latest periods?) he recommends the pouring-over of cold water as being useful in relieving the pain and curing the affection. 'Articulorum tumores et dolores absque ulcere et podagricas

affectiones . . . . frigida large effusa [aqua] levat et minuit, doloremque solvit.' Withal, his views on the hygienic value of water were remarkably advanced. He says, in the 'Tractatus de Aëre, Aqua et Locis,' that 'the first duty of the physician when he comes to a town is to become acquainted with the peculiarities of the waters used there, whether they are boggy, or hard or soft, and whether they come from hills or rocks,' &c. Since elevation of temperature was known to him as a symptom of fever, he recommends the use of cold water against the different varieties of it; even the reactionary influence of cold applications was not unknown to him, and he knew how to extract use from them. 'When tetanus attacks a young, powerful man without previous wound in the summer, copious affusion of cold water often suffices to reproduce the, in this instance, beneficial pain' ('Tr. de Usu Liquorum,' ii.) The observations, therefore, which ultimately led to the knowledge of revulsion, were as well known to Hippocrates as were those on the heat-abstracting action of cold-water applications, and he knew how to make use of them in both directions, and that too at a time when the transcendental speculations of the Pythagorean school commanded attention. We perceive also, in the introduction of therapeutical principles true to nature, the first important beginnings of hydrotherapeusis in scientific medicine. From this time water commands a place in therapeutics, and, since its soothing and anti-inflammatory properties are the most striking, we see how it is taken up by the different medical schools which crop up beside and after each other, in the treatment of the acute diseases more particularly.

The method of giving the cold bath as described by Hippocrates, the rubbings and showers, were carried on by his disciples and followers; of his numerous dietetic regulations, the one regarding the drinking of cold water in fevers maintained itself longest. In 340 B.C., however, we observe the influence of the Egyptian school getting the upper hand, and the pupils of Chrysippus of Knidos condemned the drinking of water as hurtful. Against this judgment a man contended, of whom we have the right to say that he was one of the greatest discoverers in the domains of anatomy and physiology, notwithstanding that nothing of his writings has descended to

us directly, namely, Erasistratus of Keos. Soon again, however, we find medicine domineered over by the contending philosophical systems; dogmatists and empirics fight each other, the treasury of physic increases, the teachings of a rational system of dietetics are forgotten. In this period of retrogression we see Rome, which hitherto stood on a very low level in regard to the culture of medicine, becoming medically colonised from Greece. We must assume, in the person of Asclepiades of Prusa, quite an unusual genius, when we consider the prejudice which existed in the ageing republic against physicians, hitherto regarded as slaves only, who combined the practice of a most primitive kind of medicine with some of the lowest and most dishonouring occupations. What Pliny reports of him lets us know in what high estimation he was held as a physician until the day of his death in the year 59 B.C. In his therapeutics drugs played an unimportant *rôle*, the principal one being sustained by rules of diet and hydriatic methods of procedure; in febrile diseases he adopted cures by deprivation, ordered cold water to be drunk in diarrhœa, and wine according to definite indications. Particular stress was laid by him upon the restoration of the free movements of the molecules whose disturbance he regarded as the reason of the affection, by means of rubbing, the use of which led to the recognition amongst others of the sleep-producing powers of gentle stroking with the fingers. Even in acute diseases he laid great weight upon the importance of active and passive movements; more particularly and repeatedly does he praise the great value of the bath, especially of the cold, of the douche and rain baths and shampooing. Through Asclepiades, whose well-known and successful application of water as a therapeutic agent gained for him the name of 'Psychrolutes,' the cold-water treatment obtained a permanent place in ancient Rome; the ground was all the better prepared for its reception since baths were in general use in Rome as an hygienic measure. Public bathing institutions existed before the commencement of the republic, the use of the cold river bath belonged to the gymnastic exercises, and even the douche or shower-bath (*balneum pensile*) was not unknown. Notwithstanding that the followers and pupils

of Asclepiades deviated from the lines laid down by him, and that the use of cold water was allowed to fall into abeyance, its dietetic importanee sinking under the increasing negligence and the baths of the time of the Emperors resembling Russian vapour baths (the application of cold in them being a very limited one), notwithstanding all this we find the reign of Augustus distinguished by a triumph of cold-water treatment which benefited the whole *locus standi* of medicine of that epoch. Augustus appears to have suffered, according to the description of Dio Cassius, from that affection which even to-day sends a large contingent to the thermal springs and hydropathic institutions, namely, hypochondriasis. He had, apparently by the wrong treatment of Camelius, whom we can imagine as an eager therapeutist and a courteous royal physician, been so spoiled that he could not bear the slightest draught, and allowed himself the prescribed amount of exercise only inside a dry bath; he stood 'on the brink of consumption' (Suetonius, 'Vita Aug.' c. 81), when the freed-man, Antonius Musa, undertook his treatment. How he managed to induce the over-indulged Emperor to leave his tapestried chamber and submit to an energetic cold-water treatment is not narrated; suffice it that under repeated cold showers, and the liberal use of water as drink, the invalid Cæsar soon recovered his health completely. The grateful Augustus dedicated a statue to his saviour, and granted high privileges to the medical faculty. Opposition was nevertheless not wanting to the new method, and when a nephew of Augustus died in the thermal springs of Bajæ, misrepresentation was resorted to in order to ascribe the fault to Musa and his cold-water treatment—uselessly, however, as the commencement of a cure on the poet Horace proved that confidence in the cold-water treatment was unshaken, and the successful termination of the latter served to heighten it not a little. About this time the use of cold water was a very extended one, and ordered by the physicians of different schools according to defined indications. The physiatrical school, which, founded on the materials left by Hippocrates, attached to nature's tendency to cure the greatest importance, was opposed by methodismus, which sees in the organism only a powerless, passive mass, unable of itself to do

anything against the disease, but requiring to be most energetically belaboured in order to be cured. Yet even though the founder of methodismus, Asclepiades, contemptuously designates Hippocrates' method as a 'medicatio morbi' (*θανάτου μελέτη*), even though he passes direct from Hippocrates' humoro-pathological views into solido-pathological ones of his own, and his pupil, Themison, ranges all diseased conditions into three categories—*strictum*, *laxum* and *mixtum*—the new school is unable to dispense with the fruits of the observations of the old master, and the use of water as an astringent and relaxing means plays a proportionately important part in its therapeusis. Whilst the methodists, pupils of Asclepiades, attributed the action of cold water to the contraction and relaxation with which they explained everything, Celsus, the greatest eclectic, praises it as a dietetic and therapeutic agent, and recommends it against a whole row of acute and chronic diseases, in part still agreeing with the indications established by Hippocrates, but going even much further as well. He ordinates the use of water as a beverage, washing, shampooing, the bath, drenching and besprinkling. From this period we find the dietetic rules deduced from hydrotherapeusis in constant warfare with the degeneracy entering further and further into the ranks of the luxurious Cæsarean Romans. Herodotus bemoans the universal neglect of cold baths, but the most famous physicians of the day knew and made use of their curative powers. Charmis of Massilia, who treated Seneca, knew how to inspire that philosopher with such enthusiasm for the cold-water treatment, even in winter, that he called himself a Psychrolutes. Agathinus, founder of the eclectic school, Archigenes, Aretæus, and Soranus used cold water repeatedly and in the most various forms, and that at a time when medicine was degenerating and a complex and objectless system of therapeutics flourished. Although there is much contained in Galen's voluminous works that is valuable, there is still great difficulty in picking out from amongst the chaos of curative compounds that which is in conformity with our more distinct views. Surprising data concerning the use of cold water are nevertheless to be found, especially on cold shampooing after warm baths in consuming fevers.

In the fragments that have descended to us from Antyllus, we only find hints as to hydrotherapeutical procedures; we find the application of potent simple agents like water becoming more and more seldom in the retrogression which medicine, like all the other sciences, underwent. Still, the traditions of Hippocrates and Celsus, as well as the teachings of Agathinus, are not entirely lost to view. Cælius Aurelianus ('Art. Med. Principes') gives precise directions for hydriatic procedures in various diseases, and, from the great estimation in which his works were held even in the Middle Ages, it is to be assumed that he did so successfully. Aetius uses cold water against spermatorrhœa and its sequelæ, amongst other diseases.

Finally, in the time which indicates the deep fall of antique culture, close to the end of the western Roman and the gradual splitting up of the Byzantine empires, the names of two men appear who, free from blind faith in authorities, created a better epoch for scientific genius in opposition to the insinuating progress of barbarism, and these are Alexander of Tralles (525–605 A.D.) and Paulus of Ægina (about A.D. 660). In Alexander's works we come upon a precise description of the behaviour in the bath, of the pouring upon the body of water and of friction, in addition to an exactly-rendered treatment of gout, dietetic in the abstract. Paulus recommends the cold douche against sunstroke and anuria, and swimming in cold water as an hygienic measure. If we glance over the development of medicine as a whole from the time of Hippocrates to the end of the antique period, we must confess that the expectations which we may with propriety attach to the teachings of that father of medicine have not been fulfilled. The recognition of the connection between the body temperature and diseased processes, the importance of dietetic regimen, the action of water of different temperatures on physiological processes were the essentials for the basis of a hydrotherapeusis as given by him, and might easily have been transformed into a rational system by the aid of extensions made in the domain of physiology. In the confusion of the different theorising or empirical systems, however, it never came to a rational construction upon the ground obtained, and

the barbarism of the Middle Ages threw medical science, and with it hydrotherapeusis, far behind its original starting-point.

II. Hydropathy in the Middle Ages and Modern Times, up to Priessnitz.

It was in the east that at this period scientific medicine was kept up as a tradition by the Arabian physicians. One would be inclined to think that here, where the hygienic use of water in the form of baths and ablutions had already won a wide territory for itself when Mohammed made it a religious injunction at the time when he compelled his millions of believers to abstain from the use of spirituous liquors, the ground for a powerful development of hydrotherapeutics had been well prepared; but with a paradoxy which we often meet with in the history of hydropathy, we find the Arabian physicians only anxious to enrich their pharmacology, and especially timid and prejudiced against the use of cold water.

Rhazes takes up what Galen said on the application of water most completely, and lays particular stress on its use in the treatment of acute exanthems ('De Variolis et Morbillis'), also recognising its value in fever, gastric weakness, &c.

Avicenna—designated by the Arabians 'the prince of physicians'—(†1036) speaks with much greater timidity of cold water, with whose different forms of application he was well acquainted, even to the douche and enema. He warns us from the use of cold baths in retching, nausea, and diarrhœa, and advises to individualise according to age, constitution and the time of year. He, however, points out the reviving properties of cold besprinklings (through the sieve) in fainting, asthma, and fever.

The most important dietetic physician of his day, Isak ben Soleiman (†940), also returns to the statements of Hippocrates concerning spring water. Dialectics and the pharmaco-therapeutical element predominate already with Avicenna's great opponent, Averroes (†1198). We still find in the few remaining writings of Maimonides (†1208) indications of a return to the dietetic views of Hippocrates, but all traces of the application of water as a means of cure, in a manner having a definite

object in view, are lost in the deep mantle of night which sinks over the whole science of medicine during the Middle Ages, not even the experiences won up to that period being made use of. Amidst the chaos of superstition, out of which (as the medicine of the monks) was forced the germ of sound scientific knowledge, the Salernitan school alone retained the remains of the Hippocratical traditions; apart from it we find nowhere a trace of the use of cold water, the fear of it being so great indeed that it was ordained, in an order of the Church of the year 1287, that even religious acts, such as the dipping in water of a child, should be modified, water to be poured over the crown of the head only and to be warm in winter (Concilium Leodontinum). This fear of cold water is to be considered only as a single symptom of the deeply-rooted demoralisation which had taken its stand in the fields of hygiene dietetics, aye, even of personal cleanliness, and whose terrible consequences are plainly seen on the pages of history. The necessity for a change in this direction became an urgent one by the introduction of leprosy through the crusaders, and led to the universal adoption of warm baths. One class of physicians obtained the name of 'bathers.' At this time, bathing houses and bathing rooms for the poor were also instituted. Every festive ceremony, marriage as well as dubbing of a knight, demanded preparatory warm baths; even the cessation of the labourer's work for the day was inaugurated by a bathing procession which drew through the streets with lively music every evening. The cold bath was carefully avoided notwithstanding, as was cold indeed generally. Thus we find the most renowned of the Italian commentators of the Arabians, Gentilis a Fuligno (†1398), whose 'Consilia' enjoyed the highest esteem, and who himself recommended cold sprinklings against great weakness and indolence in the functions of life, still committing himself to malicious investigations into the drawbacks of the cold bath. Although we perceive cold water to be thus almost entirely excluded from the overstocked drug treasury of the fourteenth century, yet, in its stead, the use of the natural mineral springs and, later still, of artificial combinations substituted for them, obtained a powerful and universal advance, which was not without its importance for the technique of hydro-

therapeutics. In Italy, where scientific medicine had secured for itself one other situs, and which altogether was the seat of an advanced and refined culture, the actions of natural health springs were sought to be imitated and their scope widened. We possess no certainty as to the exact time of the invention of the douche (Ital. *doccia*), but Pietro Tussignano, who lived about 1336 and described the baths of Bormio, makes mention of it under this name. We observe a reaction against the reigning mystical tendency and a return to Hippocratical principles with the beginning of the fifteenth century in Italy. Savonarola, grandfather of the unfortunate theologist and professor in Ferrara, flourishes at this period and is greatly esteemed by his contemporaries. He openly breaks with many of the subtile speculations of the scholastics, declares himself a friend of cold baths, and relates, amongst others, the astounding cure which he accomplished on the Marquis Nicholas of Este, by means of cold drenchings. In his 'Tractatus de omnibus Italiæ Balneis,' written in 1480, he devotes a chapter to cold baths and recommends them to persons of weak constitution, then in high fever and dysentery, and against the leucorrhœa of females. Finally Cardanus, who assails Galenic medicine with violent criticisms, speaks highly of the application of cold water in articular pains and gout. The close of the Middle Ages is marked by the glimmerings of a returning confidence in the endeavours of nature to promote a cure, as Hippocrates stated, in opposition to the dictations of a host of unclear technicalities. Italy, the principal seat of scientific medicine, is the one above all others we see coming forward most clearly and earliest at the time of the Renaissance. Notwithstanding that it was to be expected the exertions to promote medicine would sooner or later lead to the adoption of cold water as the most appropriate agent, especially as the Hippocratical views on the significance of the temperature of the body had become developed, we find nothing to warrant this expectation in the resulting facts. The learned section of physicians was, on the one hand, still too much under the influence of doctrine and mystery, and placed an almost unlimited confidence in the secret power of springs; whilst, on the other hand, a number of charlatans of the most contemptible kind

busied themselves with magical arts, amongst which the application of cold water held a prominent position, thus giving sufficient grounds for its falling into disrepute amongst the physicians, alas! Still these charlatans were the very means of giving hydrotherapeutics its first successful step in the domain of surgery, which was at this time a most cruel system; the dressing of wounds was performed with boiling oil, and the actual cautery took a most prominent part in their treatment. It remained so until that extraordinary genius, Ambroise Paré, took its reformation in hand. The surgeons of that period formed a separate class from the learned physicians, and resembled more one of the guilds of the tradespeople. Ambroise Paré was therefore principally self-taught, and it was only in later years that he was able to acquire a classical education by dint ot hard work, his numerous works, however, being written in French. Since he united in his person all the good qualities of a prominent surgeon with unabating zeal, acute observation, and an untainted, self-sacrificing character, he had already obtained renown when he assisted at the siege of Metz under Francis I. in 1553. Here, he reports, he 'underwent the pain of seeing the wounded, whose confidence he so well deserved, prefer a certain Maître Doublet (who was an ignorant empiric) to himself repeatedly, the only talent which this man possessed being that he applied water and charpie to the wounds with incantations, and had very good results.' Soon, however, his quick perception discovered wherein these results originated. He had already observed that gunshot wounds healed much better without the boiling-oil treatment. He now tried the treatment of wounds and fractures with cold water, and soon arrived at the most happy results; and now he declares with an amount of courage which is quite hazardous for that time, 'I declare that it is not the words' (of the incantation) 'nor the cross which do it, but the water, which cleanses the wound and protects the injured limb from inflammation and the contact of other fluids by its coldness' (A. Paré, édit. Malgaigne, t. i. p. 97).

Although thus introduced with all the authority of a surgeon esteemed both in his own times and by later generations, the use of cold water in surgery had still to fight against a strong opposing force, yet it never quite lost the ground it had gained

at a time when internal medicine closed its portals to it. Medicine in Germany was slower than in Italy in shaking off the influence of the Arabians, of Galenismus and monks'-medicine, and Theophrastus Paracelsus, a passionate opponent of Galen, who marks the commencement of the medical Renaissance period, has taken up much that is mystical into his daring system. Thus, the cold-water treatment finds no place amongst his arcana, which were directed bodily against Archæus, whilst he gives unbounded praise to the mysterious powers of the mineral springs, especially to those of his own country from teleological reasons. Nevertheless, the use of cold water was considered a very valuable remedial agent by many of the physicians of the time. Gualtherus Riff of Strasburg, Bartholomæus Viotti a Clivolo, and Ugolino de Monte Catino gave great attention to the study of baths, and lay particular stress upon the value of shower-baths. An anonymous work published in Venice in 1553, entitled 'De Balneis omnia quæ exstant,' gives the historical information concerning the use of water very completely, but with a good deal of legendary matter taken up in it. Günther of Andernach (1487–1574) lauds the pouring of ordinary water upon the skin as 'promoting excretions, inducing sleep, and lessening dryness;' and in the same spirit does Andr. Baccius (1588) recommend baths and showers in brain disease. Upon the whole, however, it was not alone with neglect that the use of water had to contend, but with direct suspicion, the result of prejudice. The more than daring etiology of the period had ascribed to the use of the common bath the universal spread of the venereal plague. This and the chemiatrical tendency of medicine, driven by Paracelsus to the height of its culture, led to the decay of water treatment, even of its dietetic use, and we find Mercurialis, who, as the most famous commentator of Hippocrates, had always kept in view the principles of that father of medicine, deploring thus in 1601: 'Balneum aquæ dulcis in febri ardente ab omnibus probatum video . . . . sed hoc remedium hodie non adeo facile in usum trahetur, quoniam homines non solent ita frequenter lavare quemadmodum consuevere antiqui.' In his practice he lowered his better judgment in favour of the popular prejudice, and placed his trust in medi-

cated drenchings and sprinklings. Daniel Sennert even had warm milk poured over hectic patients. Prosper Alpinus (1553–1617), who lived in Egypt as physician to the Venetian Consul and wrote 'De medicina Ægyptiorum,' on the other hand praises the dietetic use of cold water, and describes the Nile baths and the diseases for which they were used. Ludwig Sittala (1552–1633), about the same time recommends cold water in sunstroke, headache, diarrhœa, and colic; and Fabricius Hildanus (1560–1634) explains and lauds its curative power in frost-bites. A learned Belgian physician, Herrmann von der Heyden (about 1643), is the first who announces the discovery of a panacea in water. In enthusiastic language he ranks it above all medicines, and applies it in chronic diseases as well as in acute, which had not hitherto been attempted. He states that in an epidemic of dysentery of a malignant type he cured 360 patients with water. The chemiatrical tendency in learned medicine was, however, at that time the ruling one, and so the use of so simple an agent as water met with many obstacles, to overcome which it did not suffice that the Van Helmonts, father and son, vindicated cold ablutions and showers from the views of even their own school. The glowing zeal of an Englishman it was which first caused general attention to be drawn to hydrotherapeutics, and secured a large domain for it. Floyer lived from 1649–1714, and his 'Psychrolusia,' which came out in 1702 in London, underwent six editions in a short space of time. The author has collected in it all that which in the sacred and profane writings speaks favourably of the cold bath, and, conformably with the spirit of the age, the sacrament of baptism is not the least important amongst his arguments. He does not even hesitate to ascribe the increase of cases of rachitis (morbus anglicus) to the neglect of plunging the body under water in the performance of that ceremonial. Floyer used for his baths the coldest spring water he could obtain, and estimated their temperature, not absolutely in degrees but merely by comparison with the temperature of the atmosphere, by means of thermometers. It would occupy too much space here were we to go through the list of diseases against which he recommends cold water, as hardly one of those at present in existence would be wanting. He never appears as aught but

the learned physician, either when giving advice as to the dietetic application of the bath, or when laying stress upon the necessity for medical advice before and after the bath, in which the prejudice of the public against so handy a remedy had doubtless to receive due attention. In his own country Floyer's teachings met with spirited recognition by the physicians and others. Baynard deprecates the proceedings of the recipe traders of his times, and uses cold water in acute, feverish, and epidemic diseases, in variola and the plague.

Pitcairne, Brown, Blair, and others reported very pretty results from the cold-water treatment, and at last Smith in 1724 published an exhaustive 'Treatise on the Medicinal Powers of Ordinary Water,' in which he, in a manner most conclusive and remarkably clear for his time, descants upon the great value of water as a dietetic, dissolving, and diuretic agent. Without letting himself into a discussion on the venturesome and mystical speculations of his predecessors, his sound criticism leads him to the conclusion that the wonderful actions of the mineral springs are probably for the most part to be ascribed to the water as such. The sensation which Floyer's teachings provoked extended far beyond the circles of medicine, and not one of the works of the learned men who adopted his views obtained such a circulation as that of Hancoke, an evangelical divine, which appeared in 1723, under the title of 'Febrifugium magnum; or, Common Water the Best Cure for Fevers,' and went through seven editions in one year. Besides very long theoretical and dogmatical arguments upon the nature of fever and the alteration of the fluids, which are full of fantastical hypotheses, there is much useful matter in Hancoke's book, especially on the use of water as a sudorific, and very correct observations upon its method of operation in acute exanthemata and intermittent fever. The influence of Floyer's teachings was never quite lost in the English mode of treatment, although George Cheyne (1671–1748) complains of the neglect of the bath, and wherever the prejudice against water appeared it always met with energetic and self-possessed opponents, *e.g.* in Huxham, the great pupil of Boerhaave (†1768), in Thomas Short and in Lucas (1750), to whom we have to ascribe the credit of the invention and first application of wet packing.

William Buchan did much for the popularisation of hydrotherapeutics, and his 'Domestic Medicine,' published in 1772, underwent ten editions in thirteen years. In England, then, the country in which Francis Bacon developed the first principles of the induction current, and in which practical medicine shook off the trammels of speculation and turned its thoughts to healthy empiricism sooner than in any other, the ground for a scientific treatment of hydrotherapeutics was better prepared than anywhere else in Europe. The history of the cold-water treatment in Italy at the time we speak of, was a much stormier and more fantastical one. Here again we find the spur to a movement which, passing beyond rational bounds, naturally brought about a reaction, applied by non-professional physicians. It was more especially a certain Capuchin monk who had formerly studied medicine and whose name was Pater Bernardo, from Gastrogianna in Sicily, who, calling himself a pupil of Rovida of Aragon, excited great wonder in the whole of Europe by his extraordinary cures at Malta, in the year 1724. Ice and iced water were his drugs, the latter administered in the form of a drink (six to eight measures a day), and as an enema or poultice, the former either as a dressing or by stroking the affected part with it. The principal object of his therapeusis, which he preached with great recklessness and little clearness, was the bringing about of crises by the skin, urine, or alvine evacuations. Nicolo Crescenzo (1727) declares quite bluntly that physicians are incapable of treating with cold water ('Ragionamenti,' &c.); but Todano and Sangez (1722) go to the maddest extremes, the former being called 'medicus per aquam,' the latter 'per glaciem.' With great audacity the first-named individual explains shortly that every disease is curable by means of cold water; one must only drink it to superfluity: but cold water does not suffice for him, it must be mixed with ice and snow, and the patient must drink at least 5 lbs. every three hours. Should the patients shiver they must not be covered, since the rigors are necessary to promote the cure, as is also hunger; and therefore the patients are not allowed to eat more than the yolks of from two to four fresh eggs daily. If the patient cannot bear the cold at all, moist compresses are laid upon the liver and loins. Fainting, sopor, and other dangerous sym-

ptoms are of no consequence; it is only necessary to continue the drinking and to sprinkle the face with iced water, &c., or to lay ice upon the cardiac region if intense sopor supervene. Parturient females are just as little excepted from these rules as are children; the former have snow or ice applied to the loins to ease the labour, and the newly-born infant receives four ounces of cold water in order to drive off the meconium, &c. One consumptive patient recovered, after a fast of eleven days and drinking water for forty days. Excesses such as these did not occur singly. Sangez of Reffina explains that it is possible to cure anything at all susceptible of a cure, by means of snow and ice. In high fever he lays the perfectly naked patient on a double sheet suspended by its four corners, and covers him up to the mouth with snow. He is then swung violently to and fro until he begins to perspire. In the meantime iced water has to be drunk incessantly (Hirschel). Excesses such as these are only comprehensible when we take into account the adventurous spirit of the period, which brought forth Brown's system of stimulus and counter-stimulus. In Italy, however, we are the more surprised to meet with them, inasmuch as the medical sciences were the most advanced there. Vesal, Aselli, Malpighi, Marchettis, and others had laid a most substantial foundation for practical medicine by their discoveries in anatomy and physiology, and Santorio Santoro's researches into excretion by the skin, about the year 1614, are proof of the completeness of the experimental method, and force us to recognise the influence of the great physicists of the Italian Renaissance period. The iatro-physicists Borelli, Baglivi, and Bellini (1673–1707) refuted the theories of the chemiatrical school, and returned to the simple principles of therapeutics which had originally been dictated by Hippocrates. The reaction against those nonsensical exaggerations could, therefore, not longer be avoided, and in 1725 the celebrated physiologist, Valisnieri, published a treatise entitled 'Dell' Uso e dell' Abuso delle Bevande e Bagnate,' in which he declares himself all too vehemently in the opposite extreme against the cooling-down of water by snow and ice, and against the incautious application of cold generally, whilst he censures the audacity which ventured to handle carelessly such an heroic curative agent. The cele-

brated but unfortunate Cyrillo of Naples endeavoured to reduce the cold-water treatment to a system in an interesting manner, and reports numerous wondrous cures which were accomplished; but whilst he published a treatise in the 'London Philosophical Transactions' for 1729, entitled 'De Aquæ Frigidæ in Febribus Usu,' his teachings found no response in Naples. Michelotti and Virgilio Cocchi made manifold use of the water treatment. Antonio Cocchi speaks spiritedly in favour of cold and plunge baths—even against syphilis—but the stage of enthusiasm passed and towards the middle of the eighteenth century we find hydrotherapeutics in Italy falling into oblivion during a period of universal retrogression.

The struggle against Paracelsus, the iatro-chemical departure and its theosophical mysteries had meanwhile begun in Germany. Supported by the discoveries of Harvey and his predecessors, the iatro-chemical school stood opposed to the iatro-mechanical, which endeavoured to prove that the vital actions of the organism rested exclusively upon mechanical principles. Their leaders, discreet men who stood at the top of the scientific ladder, approached the point known as methodismus without closing their eyes to the practical advantages to be gained from well-considered eclecticism, foremost amongst them the renowned Boerhaave, professor at Leyden (1698–1738), who endeavoured with great scientific judgment to utilise all the results obtained in the natural sciences for the promotion of medicine, but still could not resist interesting himself most in the mechanical discoveries and seeking to appropriate them to the development of a system of mechanical pathology and therapeutics. In a manner analogous to the *laxum* and *strictum* of Themison, he goes upon the assumption that the universal elements of the organism, the fibres, cause the most diseases by their contraction or relaxation. He compares the action of cold baths with intermittent fever. Boerhave nevertheless still labours under the general fear of cold water in these his views (*hoc remedium non proponitur nisi in desperatis casibus*). A freer spirit had however been introduced into medicine with his advent, and soon the experiences gathered especially in England in cold-water treatment began to make an impression upon the medical world of Germany.

The actions of water as a beverage, as a bath, or as a shower-bath began to be gradually known in the course of time.

To the use of cold baths in England attention was first drawn by John Gottfried de Berger (1658-1736), in a work on the thermal springs of Carlsbad. Vitus Riedlin, of Ulm, popularised the doctrine of the water cure by a German publication which he brought out on the subject. A work of D. Daniel Fischer ('De Remedio Rusticano variolas per Balneum feliciter curandi;' no date) speaks of the treatment of variola by luke-warm baths, which are replaced by milk or whey baths in the stage of drying-up of the pustules, as if of an old household remedy.

Of most value for the proper estimation of its worth, was the great importance Fried. Hoffmann attached to the medicinal actions of water. This leader of the mechanico-dynamic school was celebrated both as a physician and as an author; a prominent, philosophically-educated genius, he was led to the use of cold water partly by his studies of the old masters, partly by his own researches. His searching critical examinations into the actions of the mineral waters led him to ascribe them almost entirely to the pure water; in different writings he explains the actions of cold and hot baths, and calls the former, in accordance with Boerhaave's solido-pathological views, a 'tonica et elastica vis motrix partium solidarum,' acting especially on external parts, but also on the stomach and intestinal canal. In explaining the neglect of cold water by pointing to the fact that the physicians only pay attention to the blood and fluids of the body without noticing the tone of the firmer tissues, he is only drawing the inferences which Boerhaave must have ultimately arrived at with his views. Diseases the result of too rapid circulation are treated by Hoffmann with the cold bath; in high fever, cholera, dysentery, colic, cramps, &c., he recommends the drinking of cold water, whilst he brings a great amount of reading to bear against the use of the shower-bath.

Schwertner, of Jauer, gained access for foreign literature concerning cold water into Germany, and in 1749 Sommer translated Floyer's 'Psychrolusia' into German. It was Van Swieten, the founder of the older Viennese school, who was the one of Boerhaave's pupils that lauded cold plunge and shower

baths even in paralysis. Whilst he laboured for the practical application of hydrotherapeutics, De Haen (1704–1766) developed a complete system of pathological thermometry, and was able to prove some of the most important facts bearing upon it—for instance, the elevation of temperature during the cold paroxysm, which was of far greater importance for the later theoretical development of the science. The day was still far distant when hydrotherapeutics would be reconstructed upon a scientific basis, yet its importance became more and more clear to the meditative and learned physicians whilst at the same time a host of popular writings came out which advocated the water cure; soon fanatics appear upon the scene who make of cold water a dogma, and of the generalisation of the new panacea a life-long labour. Prominent are the labours of the medical family of the Hahns, foremost amongst them Johann Sigmund Hahn (1696–1773), who was a practical physician like his father, Dr. Sigmund Hahn (†1742) at Schweidnitz, in Silesia. The latter himself esteemed water as a dietetic agent very highly, bathed in cold water to the day of his death, and in a dangerous epidemic succeeded in saving his elder son, Johann Gottfried's life by water treatment. The younger son was the one who advised water to be used in all diseases and by every one, adopting in his writings a popular style which gained a great circulation for them; nevertheless he did not fall into the vulgar tone and blundering exclusiveness of the water fanatics and 'Nature's physicians' (as they might have styled themselves), as his medical knowledge was not impaired by these studies. He was still too much hampered by the iatro-mechanical views to successfully reduce the water cure to a scientific system, but he bravely contested many prejudices, and succeeded in drawing the attention even of learned circles to his teachings. His brother, J. Gottfried Hahn, minutely describes his own illness in his report upon the spring epidemic of 1737 at Breslau; this epidemic was, beyond doubt, one of typhus fever. He declares that when all other means had failed he had recourse to water at the advice of his father, and obtained good results with that agent. Both brothers are quite clear in their conception of the object of the water treatment in fever patients; they recognised the elevation of temperature — by the thermometer — therefore it was

necessary to cool the body, and this they accomplished by means of spongings as well as by baths, cold compresses, showers, and cold enemata; ice was used for wounds, erysipelas, and local inflammations, the existence of an exanthem being no contra-indication. J. Sigmund Hahn opposes very energetically and at great length the supposition that water drives back the evil fluids. The great value he attaches to dietetics shows him to have been far in advance of his time, when we remember that it was the period of vitalistic doctrines, and the energy with which he advocates fresh air in the sick-room reminds one of the acute pen of P. Niemeyer. The success of the Hahns seems to have been a brilliant one in its results. Theden, the celebrated personal surgeon of Frederick the Great, treated the severest injuries as well as small-pox and malignant fevers, rheumatism and joint inflammations according to Hahn's principles, and made special use of the shower-bath, the method of which he improved considerably. Notwithstanding this, the method met with little encouragement from physicians as a whole; this may have been due, as it was in Italy during an earlier period we have just discussed, to the charlatans possessing themselves of the subject and bringing it into disrepute. A letter concerning a certain Dr. Krüger, of Hildesheim, which Jürgensen gives in his 'Behandlung des Abdominal-Typhus,' proves how carefully water was handled in those days when it was thought necessary to use it in treating febrile diseases. It runs thus (A.D. 1759): 'I should not like to imitate that of which Krüger dreams, and to justify which he cites the case of a medico who, wishing to cure happily, had to use quite contrary and most extraordinary means to achieve his object now and then, and as an example of which he relates how a certain professor saved the life of his son, who was already given up as hopelessly lost, by wrapping him up in cold and wet cloths. Still less would I like to imitate that which I know of the empirics who have cured by pouring cold water over the patient. I have tried it' (the water) 'in three patients with rigors, in whose cases I knew not what to do, but not beyond *wetting the inside of the hands and striking the forehead with linen, fourfold and wetted* . . . but I was not inconsiderate enough to experiment any further in this line . . . since I feared that our old-fashioned doctors would blow

the trumpet about it.' Jürgensen asks, Would the same caution have been exhibited in making use of an experience concerning an orthodox pharmaceutical remedy?

The prejudice of the physicians as well as of the people still stood in the way of the universal dissemination of hydrotherapeutics. The prejudice of the former was to be overcome by the scientific foundation which it had obtained in England, that of the latter by the doings of the water fanatics in Germany.

In France we observe that attention is attracted to water towards the end of the seventeenth century, when a swindler named Barbereau is unmasked, and the panacea which he sold in well-corked bottles under the name of 'the everlasting spring water,' with which he performed miraculous cures, is discovered to be common water. This was seized upon with zeal by many physicians as a proof of the healing properties of water, and as the results were not wanting they were explained by the existing theories. Hecquet ('Médecine des Pauvres,' 1740) arrives at the conclusion that water is the only drug which fulfils the indications he sets up in very unintelligible language, these being to restore to the firm tissues of the body their elasticity and to protect it when regained.

Geoffroy explains, in an answer to the prize question propounded by the medical faculty at Paris, that water is the best prophylactic against the plague, 'and,' he declares, 'it is more than that even; it can be shown that it is a universal agent —out of place in no disease, and, in many cases, a specific.' Noguez attempts the physical explanation of the influence of the cold water ('Les Vertus Médicinales de l'Eau'): 'Under the double influence of cold and of the weight the capillaries contract and drive the blood quickly and energetically back; at the same time the pores get narrowed and prevent the evaporation from the skin, from which it may be concluded that there is nothing better than the cold bath for steeling oneself against the cold and for carrying off the tough and sticky humours which take up their abode in the capillaries and give rise to constipation, gout and rheumatism.' The explanations of Pomme, who introduced baths of excessive duration into practice, are more of a dynamic nature, and were generated under the influence of the theory of irritability. Extravagances

such as these caused opposition, naturally, and challenged satire perhaps because there were always a certain number of adherents. Thus we find in the classical novel of that time, 'Gil Blas,' the character of the water-doctor represented, being in this case supposed to be meant for Hecquet. The use of cold water got still more popular despite these satires ; even the adherents of the chemiatrical school, like Peter Chirac (1735), whose lucky cures created great wonder, praised it loudly, and in 1731 Le Drau introduced the douche. Tissot, one of the most honoured physicians and the most important of popular medical authors of his time, laboured more than anyone else for the promotion and general estimation of the cold-water treatment. He recommends the cold bath, the continual drinking of ice-water, and even the long-continued baths of Pomme against nervous diseases which have originated by the over-stiffness of the fibres, the stickiness of the fluids, and the lessening of the evaporation. Later on he comes back to the usefulness of the tepid (53·3°–77° F.), and cold (32°–53·3° F.) bath, which he designates as the most efficacious and powerful tonic and one of the best remedies for epilepsy (ii. 363); he also lauds the influence of cold wet abdominal bandages, and of the internal use of cold water in certain forms of bilious fever. Tissot, in the most important of his numerous popular writings ('Avis au Peuple sur la Santé,' Paris, 1770), likewise recommends the hygienic use of cold ablutions for children, in order to strengthen them and lessen their sensibility to changes of temperature. Marteau entered more into the actions of the bath, particularly of the douche, in answering a prize question given by the Academy at Bordeaux in 1767. Grimaud (1750–1785) keeps to the indications laid down by Tissot, but, in addition, pushes forward the antispasmodic virtues of water as observed by him in experiments performed on muscles affected by clonic spasms. All these recognitions paid to the cold-water treatment by scientific medicine were, however, without an exact scientific basis, cold water being with very few exceptions, used altogether empirically, or it was endeavoured to explain its actions so as to suit the dominant pathological system of the day. According as the tendency was to solido- or to humoro-pathological views so had water to act, sometimes relaxing or softening,

at others moistening or diluting, and so on. A physiological study of its actions had never been undertaken. At the time that great discoveries were being made in physics and chemistry, medicine had not got beyond the point marked by Haller in the land of Lavoisier's nativity. Facts, however, worthy of the observer's attention stand at the side of the theories and hypotheses; but coupled as they are with the unstable doctrines of the time, they sink into oblivion, and thus it came about that in the 'Nosographie Philosophique' of Pinel, published in 1798, there is hardly a word about cold water. The scientific birth of hydrotherapeutics certainly took place about this time, but in an adjacent country. Of much more lasting importance was the introduction of cold water into surgery, which occurs in the epoch just mentioned. It was owing to Lombard and Percy, and the latter, one of the most important and energetic writers in the domain of surgery, describes it in the following manner, which reminds one forcibly of Ambroise Paré: 'At a trial of guns which took place at Strasburg in 1785, several artillerists were wounded by the bursting of a gun; they were conveyed to a field hospital of which Lombard was head, and, with Percy's assistance, that surgeon placed the primary dressing upon the lacerated wounds and bruises *secundem artem.* Rumours soon spread the account of the accident through the country, and an Alsatian miller presented himself before the commissioner of the province with the announcement that he understood how to transform common water into an unfailing remedy for healing wounds. He so thoroughly succeeded in convincing that gentleman of his infallibility that the wounded soldiers were placed under his exclusive care, and, in order to enhance the value of the charm, neither Percy nor Lombard was allowed to be present during the dressing, until some time later, and then only on three different days—the 12th, 20th, and 30th—of the treatment. The miller cleansed the wounds with river water, into which he cast a white powder whilst murmuring unintelligible formulæ; the powder was subsequently recognised as alum. The wounds having been well washed out, they were covered with charpie, which was dipped in water whilst the gesticulations continued and holy sayings were recited in a low voice.' Eleven severely

wounded men recovered under this treatment within six weeks and without very great pain. 'This lesson,' adds Percy ('Dict. des Sciences Méd.,' x. pp. 477–480), 'was not thrown away upon us. We admitted that we might not have succeeded in bringing about a cure so rapidly and conveniently by means of the usual treatment adopted, but we did not hesitate to maintain that in a similar case we could obtain the same results, if not better ones, with simple water than the miller with his incantations, for testing which assertion we unfortunately too soon had an opportunity. Once more there were artillery trials, in consequence of which we received thirty-four wounded under treatment, all of which were dressed by Lombard with pure, lukewarm or cold water, no other treatment than the application of the necessary splints, bandages, and mechanical aids being resorted to. Notwithstanding the severity of the injuries and the serious complications, all of these men were cured by the forty-fifth day.' In the year following (1786) Lombard published his report on the local application of water in surgery, in which he actively combated the prejudices which existed against it, more especially the fear of applying water to wounds of the head; in erysipelas only he prefers warm to cold water, whose field of healing power he greatly extended. His assistant, the renowned military surgeon Percy, went much further, his manifold and tried experiences gathered on innumerable battle-fields making him an authority in surgical science. 'Sydenham,' he exclaims, 'would not be a physician without opium; I would have given up military surgery had the use of water been forbidden me.' Percy's very thorough and exhaustive labours secured to the cold-water treatment its place in surgery for ever, and later researches up to the present time have added little that is new to them.

The last decades of the eighteenth century were to prove eventful for the history of hydrotherapeutics in England. Dr. Wright, director of the military hospitals at Barbadoes, whilst on board a vessel sailing from the West Indies was attacked by an epidemic fever which, imported at Jamaica, was raging on board the vessel. Convinced by his experience of the inutility of all other means, he tried the treatment by shower-baths of cold sea-water upon himself, and succeeded not only in bringing

about his own recovery, but also that of other patients whom he similarly treated. Brandreth obtained like results after him. Wright continued his treatment in Edinburgh with great success. Attracted by its publication in a medical journal in 1786, James Currie, a practical[1] physician in Liverpool, placed himself in correspondence with Wright; and in 1787, when a contagious fever broke out in the Liverpool Hospital and began with a high rate of mortality, he resolved to apply Wright's method to its treatment. Currie was an independent, free-thinking man who boldly criticised the theories of the day, especially in England, where Brown's theory of hyper-asthenia, founded upon Darwin's vitalistic system, held full sway with its practical attendants, the excesses in counter-irritation. His criticism was just as equable as it was clear and decisive. He is actuated by this same critical, natural philosophical spirit in his hydrotherapeutical experiments on typhus, angina, and (with Gerard) on the acute exanthemata, &c.; further, in intermittent fever and others. (He also draws the reports of Jackson and Maclean on the cold-water treatment of yellow fever in the tropics into the circle of his reflections.) He shows a large number of cases, yet his method is not a statistical one; the favourite 'average' does not exist for him. In lieu thereof, each case is individualised, and each step of the treatment controlled by the thermometer; each symptom traced to its connection with the heat processes in the organism, if possible; and a series of physiological experiments, carried out with great care and conscientiousness, winds up the observations on the patient. Currie, by virtue of his observations, thus came to the recognition of the constancy of the animal heat of the body, and of its great significance in regard to health: 'We have reason to believe,' he says on p. 200, 'that as long as the real temperature of the human body remains unaltered, a change of temperature in the surrounding medium does not cause any lasting deviation from health; but that, on the other hand, very few degrees of increase or decrease in the heat of the body are followed by

[1] The term 'practical' physician is essentially a German one, signifying one who is qualified in medicine, surgery and midwifery, and possesses a State diploma. There being no equivalent in English beyond the term 'general practitioner,' I have adopted the word 'practical,' as more suitable.—TRANSLATOR.

disease and death. It seems, therefore, that the knowledge of the laws by which animal heat is regulated is one of the most important branches of physiology.' He has also a clearer conception of the sources from which the body draws its heat than the youth of Lavoisier's discoveries and the absence of chemical investigations would lead us to expect. He likewise differentiates exactly between heat production and radiation, and endeavours to estimate the value of cutaneous transpiration in the heat-equilibrium. Currie used a most ingenious and yet simply constructed maximum thermometer for taking his temperatures in contagious diseases. He took them in the axilla, in the mouth, and between the thighs and scrotum; in the bath only in the mouth, endeavouring by curving the thermometer to an appropriate shape to obviate any modification of the temperature by the air of respiration. His examinations are not confined to the heat-economy of the body by any means; but in cases of inanition and on healthy persons, he studies the question of absorption by the skin by the aid of theories, and although he does not arrive at any positive results, his method of investigation and deduction is still worthy of imitation. In spite of this eminently physiological tendency, Currie is not tainted by the scepticism of later schools, but, practical physician that he was to the core, animated only by the desire to cure, and the knowledge that he was able to contribute to that object, he does not deny absolutely the value of the usual medication of the day in febrile diseases—it consisted chiefly in opium, antimony, Peruvian bark, and strong wine—but merely comes to the conclusion that cinchona and opium are useful adjuncts to the cold-water treatment. In addition, he recognises the great value of hygiene and dietetics; and that which he writes concerning the usefulness of fresh air and of disinfection in hospitals, as well as the relation of the latter to infectious diseases (p. 256), has since been recognised to the fullest extent and found to be correct in all its bearings.

The principal part in his cold-water therapeusis is sustained by the salt-water showers, in addition to bandaging, hip-baths, and the internal administration of cold water; the sea-water is of comparatively low temperature, and he ascribes a better influence to it than to fresh water. He considers perspiration

to be a self-cooling of the organism; the cold-water procedure is therefore unnecessary during its presence, and he warns us never to adopt it during the cold stage of intermittent fever on account of the collapse which is sure to ensue. He likewise used cold water in tetanus, paralysis, gout, convulsions, &c., with good effect, and what he contributed in the way of facts bore the stamp of genuineness so plainly that even decided opponents did not dare to doubt them, and although there were many enemies, the new method soon gained numerous adherents, further experiences gained in England and Germany serving to support and spread it. Some of these disciples were Gregory, Falconer, Dymsdale, Nägle and others. In Germany Currie's works were made known in 1801 by Michaelis' translation of them. Müller in Minden (1778) and Brandis in Kiel (1786) had already gathered similar experiences; the latter had indeed treated hectic patients with cold baths, reverting to Galen's procedure, and was later on one of the first who recommended the cold-water treatment in cholera. In Vienna the cold-water treatment of typhus and the acute exanthemata was introduced by Joseph Frank in 1803. A son of the renowned Peter Frank, he was at first an enthusiastic apostle of Brownianism, but after his return from London, where he had seen and studied Currie's treatment, he introduced it into the Viennese hospitals, where it was soon established by reason of its favourable results. Joseph Frank soon left Vienna to settle at Wilna, but the system he had brought from England soon spread further than Vienna. Kolbany in Pressburg published a large number of successful results observed during several epidemics of scarlatina and typhoid, and through these the attention of Fröhlich was drawn to the cold-water treatment, which he extolled in numerous important writings.

Whilst the number of physicians who spoke in favour of the cold-water treatment of acute diseases rapidly increased, the dietetic importance of the cold bath and its application to chronic diseases attracted distinguished and universal attention. Ferno, in 1781, erected the first river-bathing institute at Vienna, and recommended cold bathing in a host of diseases. But no one laboured so indefatigably and importantly for the general advancement of dietetic knowledge and the recognition

of the importance and high value of cold water as Hufeland (1762–1839), the great medical eclectic so highly esteemed both by physicians and the laity. Whilst he understood (like Tissot) how to awaken healthy hygienic views in the mass of the educated classes by his popular writings, couched in happily-chosen, original language, he put forth in his technical works mild but still decisive arguments against the Brownianism still existing, as also against the theosophical mysticism of Röschlaub. By the labours of Hufeland, Vogel, Lichtenberg and others, sea-bathing was at length placed in the treasury of German therapeutics, whilst in England it had been honoured, practically and in literature, long before. The result of activity such as this was that the fear of the use of cold water, which had formerly been so prevalent amongst physicians as well as populace, gradually gave way to a more healthy view, and thus it happened that the treatment of typhus with cold water during the fearful epidemics of 1810, 1813, and 1814 had not to contend with such obstinate opposition as formerly, and was able to produce extraordinary results. Mylius in Cronstadt, who used no medicine beyond a peculiar cold-water treatment, had astonishing successes. His patients were wrapped in a sheet and then dipped three or four times into a bathing-tub filled with cold river-water—water being poured over the head as well—then placed on a mat, rolled out of the sheet, put into a dry bed, and enveloped in blankets. The same treatment was resorted to successfully in chronic nervous affections. Hildenbrand of Vienna and Horn of Berlin attach great importance to change of the air in addition to the cooling-down obtained by baths and drenchings, and the latter says: 'Had I the choice between placing the typhus beds in a narrow place, unapproachable to light and air, or beneath the open sky, I would prefer the latter.' The English method had so many active apostles that their enumeration here would lead us too far out of our way; but, as a proof of the lively interest this topic excited in medical circles at the time, we may quote the prize essay given by the Hufeland Medical Association in 1821, the subject of which was the external application of cold water in fevers accompanied by high temperatures. Fröhlich's work received the prize, and gave a copious list of practical therapeutic experiences. Beside it, the works of Reuss

and Pitschaft were thought worthy of publication amongst those sent in, the former being of a practical nature, whilst the latter took up more the literary, historical part of the subject. Intelligence concerning successful cures by the cold-water treatment becomes more and more frequent after this; more attention is devoted to the baths, and a rich literature occupies itself with the vapour-bath alone, now becoming so popular. But still a sufficient tribute is not paid to hydrotherapeutics; indeed, the undeniable successes attained by it are still looked upon with a certain amount of distrust. The reason for this phenomenon is to be found in the peculiar phase of development which medicine had to pass through in Germany in the first quarter of our century.

The period of the great discoveries in the natural sciences was a very agitated one for even the purely speculative departments, and in the domain of medicine there were two tendencies, the one to place it, like the natural sciences, upon a positive basis, whilst the other allowed all that was deductive or even fantastical and mystical to take the lead; the first-named appeared earliest in France and with many extraordinary errors. The high standing which Bichât, Magendie, Baillie, &c., had obtained for physiological and pathological anatomy, soon made the endeavour to transform practical medicine into a science apparent, anatomical and physiological principles being the basis upon which it was to be reared. The sanguineness of this school (Broussais, Bouilland) at first had a very perceptible influence in Germany also, and was not favourable to the development of hydriatic principles. The physiological tendency culminated in Laennec, the genial investigator, who took up Auenbrugger's (Vienna) discovery of percussion, and, with auscultation, introduced physical diagnosis into medicine. The attempts to place pathology upon a firm anatomical base kept pace with the endeavours to obtain an exact, scientifically-grounded system of therapeutics; without, however, arriving at a like result, for doctrine still held sway, and upon Brown's stimulismus and Broussais' irritation doctrine followed Bouilland, who established rational indications for the *saignées coup sur coup* (of such melancholy renown), upon anatomical grounds, the slight stability of which was only to be discovered later on. This school did not show itself in its complete radical extent in Germany, and it

was also successfully opposed in its own country, particularly by Louis, and later on by Andral.

'The great physiologico-chemical discoveries by Priestley, Lavoisier, and other investigators had too dazzling an effect upon sanguine therapeutists to be resisted, and soon we perceive new doctrines cropping up which look upon diseases as either an excess or deficiency of oxygen in the system, and seek to adapt their therapeusis to the circumstances accordingly. Baumes in Montpellier appears upon the scene with a nosological system, according to which the diseases are divided into five classes, of which the misproportion in the amounts of oxygen, carbonic acid, hydrogen, nitrogen, and phosphorus forms the basis. The investigations of Andral and Gavarret (classical, as such) led to the formation of an apparently conclusive theory of crases, and assisted the humoro-pathological views to unlimited sway; yet, therapeutically speaking, they were unfruitful; theoretical chemistry became, in fact, practical nihilism' (Petersen, 'Geschichte der Therapie'). It is easily understood then, how impossible it was for hydrotherapeutics to obtain a quiet abode for its development and dissemination amongst the numerous systems having such different views, yet firm in doctrine.

But in Germany even—where the already-mentioned works of Fröhlich, Reuss, and Pitschaft had prepared a scientific soil for its growth, where the clear eclecticism and popular importance of Hufeland had obtained access for it into the widest medical circles and educated society generally, and where eminent therapeutists were working at its preparation and the elaboration of its remedial apparatus—even there it was not scientific, recognised activity that led to the thorough success of hydrotherapeutics. The struggle of the systems continued in Germany, and the influence of Schelling's natural philosophy made itself perceptible in a peculiar manner. We perceive a retrogression to the mysticism of the Middle Ages in the medical writings of a Röschlaub and a Ringseis, just as we see the romance of the Middle Ages raising itself in the literature of that time. Röschlaub was influenced by Paracelsus and his teachings; his much more impulsive pupil Ringseis seems to incline to the sacerdotal physicians with his seemingly pious tone and theurgical teachings. How often do we see, coincidently with an active step on

scientific territory, an increasing similar tendency to the mystic and incomprehensible manifesting itself in various ways, naturally enough more closely related to popular life. A therapeusis had to form itself out of this chaos at a time when scepticism amongst the learned became every day more apparent in existing scientific therapeutics, and did not escape the notice of the public, although they but little understood it. The enormous success of animal magnetism, and the mysterious excitement it was able to create at a time of the most advanced understanding, is easily explained by this approach towards the mystic. We may consider homœopathy a sort of compromise, the result of the dual impressions of mysticism and therapeutical scepticism, or rather nihilism. Its founder has skilfully veiled his mystical views in seemingly scientific language in his writings, which allow the natural philosopher to be recognised, less in their style than in their contents. His therapeusis was certainly as innocent as the nihil of the sceptics, and it is not to be denied that he laid more stress upon the importance of dietetics than had hitherto been the case. As he exhibited, unintentionally, to the medical world the superfluity of many previous therapeutics by his results, it is certainly not to be deplored that homœopathy found many adherents amongst the people and even in educated circles. The number of homœopathic doctors could easily become a very large one, as it was not necessary for a candidate to be possessed of any medical knowledge whatever. It sufficed to observe correctly the objective and to note the subjective symptoms, and then to dispense the ten-millionths accordingly. The general and partly active sympathy of the public stimulated this system to take active part in the polemic against learned medicine, a part which it relished not a little. Physicians of nature cropped up, and the greater part of their writings was taken up by petty polemic against the social physicians; the less they were able to test critically the theory which they preached the more fanatic they became over it, and they knew how to impart the fire of their enthusiasm to the excited and therefore gullible public, the causes of whose excitement we have already discussed above. That which we saw in Italy a century before under Sangez and Todano, now repeated itself. The idea that a cold-water treatment could emanate

from prominent scientific men (some like Currie) who were educated physicians, far in advance of their time, and be by them proved, grounded rationally and practically applied with success, could not be driven into the heads of the populace. It was therefore taken up by medical laymen and preached as a dogma. Cold water was extolled, as in the time of the alchemists, as a universal remedy, and this time a lasting result was obtained. Through the hands of nature's physicians hydropathy had to pass in order to come again under clinical examination, to obtain a scientific foundation, a wise restraint, and permanent value.

III. Hydrotherapeutics and the Physicians of Nature—Oertel, Priessnitz.

The writings which appear to have worked so energetically upon the gymnasial teacher Oertel[1] in Ansbach that he imagined himself ordained to bring about a new epoch in medicine (perhaps in the whole of social and moral life), after he had experienced the curative powers of cold water upon his own person, were those of the elder Hahn (Johann Sigmund). In happy ignorance of really medical literature, and unacquainted with the physiological researches of modern times, his vindication of cold water served him also for a war-cry against the physicians. In his numerous writings abuse of the medical profession was his leading motive, to which he added a collection of all that which was ever written in praise of cold water, but couched in trivial, uncouth language, and interspersed with old-fashioned and even scurrilous witticisms. To him, water seems the true panacea, and his motto runs: 'Drink water to excess, the more the better, for water is good against everything.' True to his motto, he brought out a number of independent publications in its favour, and re-edited, or rather re-wrote, some of the older writings upon hydropathy, *e.g.* those of J. S. Hahn, Floyer, Fr. Hoffmann, Hancoke, and Smith. These physicians are the only ones, however, whom he considers worthy of his notice. The less medical science is able to impress him, the more childlike faith he places in the contributions of the natural physicians and miracle-workers, such as the

[1] See literature of 1830–39.

barber's boy, Bleile, and the cobbler's assistant, Schatz, humbugging charlatans of the most ordinary caste, who were able to call forth his admiration by their wonderful cures something after the style of Baron Münchhausen. Only one of the natural physicians was unable to impress him or to win his favour; in fact he only noticed him in order to make him the object of spiteful side-thrusts or direct attacks, although this man was just the one who was to inaugurate a new and really significant era in hydropathy—and this man was Priessnitz.

On the Gräfenberg in Austrian Silesia, 1,800 feet above the sea-level and in one of those neat little farms which are scattered over the hill-sides of the Sudeten, Vincent Priessnitz was born in 1799. The powerful talent and youthful seriousness which was peculiar to the peasants of Silesia in general, was advantageously developed in him by a more careful education; and scarcely out of his boyhood, he already made the observation in agricultural pursuits, that it was possible to obtain a comparatively rapid cure in sprains, contusions, and swellings of horses' feet by the use of cold-water bandages and compresses. As soon as he had ascertained the fact, he turned his experience to other domestic animals, and as success always attended his attempts, he reposed great confidence in the healing power of cold water. His patients of that time do not seem to have been very grateful ones, for in 1816 a horse threw him and injured his face and thorax with his hoofs. A country surgeon who was called in, exerted himself until he had exhausted his own and the injured man's stock of patience in the endeavour to bring the broken ribs into a position for uniting favourably, and when he could not succeed in this, he declared that even if the patient were to escape the present imminent dangers he would have to face long suffering and lasting deformity ever afterwards. Naturally unsatisfied with this verdict, the young veterinary surgeon resolved to attempt his own cure. With the energy so natural to him, he first of all pressed his chest against the corner of a chair, and then, holding his breath, he brought the two broken ribs into their normal position with his hands, fixing them there by means of a dressing formed of towels steeped in cold water; then he drank water copiously and repeatedly, and found himself cured

in a short time. That which his strong constitution had worked for him, he ascribed to the agency of his great drug without a moment's hesitation, and at once set about examining the *modus operandi* of the bountiful cold water with admirable zeal and endurance. In order to arrive at a knowledge of the laws of heat-deprivation, and its application to diseases in man also, he commenced experiments almost touching in their *naïveté*, and drew his conclusions therefrom with most happy sanguineness. For instance, he killed two swine, one of which was fed exclusively on cold, the other on warm food, and found the intestines of the former white, elastic, and resisting, whilst those of the latter (warm-fed) animal were red, softened, and easily lacerated to such a degree as to be unfit for the preparation of sausages.

Priessnitz's forte lay neither in physiological knowledge nor in being medically well-read, but having undoubtedly an original, thinking head, it is to be assumed that he came upon a method independently which Hancoke had applied 100 years before him, had converted into a system, and had recommended, namely, the bringing-on of heavy (so called) critical perspirations by cold-water procedures; these consisted in friction and packing, to the absolute exclusion, naturally, of all or even of diaphoretic medicines. Having had a few lucky results in the treatment of gout and rheumatism, which created great excitement in the neighbourhood, crowds of persons seeking relief poured in on him from all sides. His simple manner, combined, however, with a firm, overweening self-confidence, the moral effect of which is certainly not to be underrated, made itself so telling upon the naïve inhabitants of the hills that they considered him to be chosen by Heaven to minister to mankind, and the power which cured the sick in their eyes did not depend on the water, but on the personality of Priessnitz himself. Soon sufferers came from afar and out of the better classes of society, who were all treated in the same routine manner, independently of diagnosis, and without regard to disease, age, or sex. This routine comprised a certain diet, 'according to the natural laws,' *i.e.* powerful, coarse, non-irritating but liberal; strong muscular exertion, the drinking of great quantities of cold water, the different forms for the external application of

this material, amongst which the general and local baths, the excitant binders, the douche and friction were the most important factors; lastly, the procedures to cause sweating, *i.e.* packings, which were carried to the length of six hours and more.

The modifications which this procedure underwent in individual cases lay within very narrow bounds, since Priessnitz, so fanatical about his hobby, had no means of making a diagnosis; some hard experiences could therefore not be avoided in phthisical and cardiac cases. Warned by these, Priessnitz soon excluded patients the subjects of cough and serous effusions (ascites and anasarca) from his treatment. Undaunted by the agitation against himself which this misadventure served to nourish, Priessnitz obtained the consent of the Government, in 1830, to the opening of an establishment to be conducted on his principles. In that year he collected forty-five patients there, but the number increased in fabulous progression, and in the year 1840 he accommodated already 1,576 patients, which number grew yearly by new-comers from every part of the globe.

Priessnitz died in the year 1852, worth several millions.

If it is at all possible to speak of a pathological basis in connection with Priessnitz's method, it was one emanating from the humoro-pathological views, such as the mode of thinking of the medically uneducated might easiest accommodate itself to. All diseases originate, according to him, in the alteration of the humours of the body, and according as these 'bad humours' circulate through the system at large or concentrate themselves in one organ, so do general and local affections arise. To restore the harmony in the activity of the organs, upon which health in reality depends, it is absolutely necessary to attack these evil humours, to drive them out and to replace them by healthy ones; the healing power of nature, however, is alone able to effect the desired cleansing. It is therefore only required to put nature into a position to do away with these evil humours to open the road for a cure; and in cold water he discovers the means of doing so. Used internally, it loosens the choked-up fluids; its external application draws them to the skin, and by means of powerful diaphoresis they are removed from the body. Critical movements indicate the beginning of the cure;

a simple and supporting diet, and violent bodily exercise (not gymnastics, but after true peasant's fashion) work towards the new formation of healthy fluids. Every violent reaction—and that the most varied reactions took place under this energetic treatment need hardly be mentioned—in the course of the cure was welcomed with great rejoicing as a crisis. At one time, various affections of the macerated and irritated skin, erythema, eczema, furuncles, and even extensive phlegmons, constituted some of these crises; at another they were gastro-enteric symptoms, vomiting, obstinate diarrhœa, or even alterations in the urinary secretion, hæmorrhoidal and uterine hæmorrhages or salivation. These crises always signified the approaching cure, and Priessnitz would then naïvely apostrophise his patient thuswise: 'Thank the healthy inner power of your constitution, which enabled nature to drive out the offending humours that had rooted themselves in your body.'

We are fully entitled to date a new epoch for hydrotherapeutics from the time of Priessnitz's appearance. His outward success was, as we have seen, a most brilliant one, and his method had found general acceptance in the lay world; his fame spread over the boundaries of our division of the globe, a copious hydropathic literature sprung up, and institutes after the pattern of that on the Gräfenberg grew on the soil of Germany and the neighbouring states. Soon the at first inimical bearing of the physicians was changed into one of intense and critical attention and we see hydropathic institutes conducted by scientific physicians of most thorough education, whilst cold-water treatment, of the acute exanthemata first of all, is theoretically and experimentally justified, then adopted for numerous chronic forms, and thus was hydrotherapeusis secured in its present important and probably more lasting seat in the list of medical labours. Yet there is much in the career of Priessnitz and of his ardent followers which reminds us of the epochs in earlier centuries in which the cold-water treatment, pushed with fanaticism by non-medical men, greeted with joy by the public and ignored by physicians, was soon forgotten and allowed to sink into oblivion. Wherein lay the grounds upon which hydropathy this time obtained such a decided, universal, and lasting recognition? The history of medicine has undergone

great and weighty revolutions, it must be acknowledged. The therapeusis of former centuries rested on theories which were adhered to like dogmas. As soon, then, as these gave way before the progress of the natural sciences, it was found that the ground upon which the whole artistic edifice of therapeutics had been reared was undermined. The most upright and ingenious endeavours of the scientific schools, pathologico-anatomical as well as physiological, could not succeed in lending to medical labours, which had up to this time enjoyed the characters of art, of intuitiveness and the subjective (*medicus nascitur*), the security of exact science. The Viennese school, the most advanced of all, declared itself in favour of therapeutical nihilism, and the practical problem of the physician soon seemed to become a negative one as the expectant or do-no-harm treatment became the exclusive one. Reason enough why the laity—to whom this movement did not remain secret, although they failed to comprehend it clearly—should turn to any direction in which they were promised an efficient method of cure, recommended by accomplished results, with enthusiasm. Homœopathy gained considerable ground at Vienna, in whose school therapeutical misbelief had originated; a hospital was even erected for its working (Petersen) during the third decade of the century, and—homœopathy really cured its patients perhaps not *propter* its doses, whose minuteness must exclude any material action when scientifically considered, but still certainly *post*. Homœopathy with its mystic dynamical principles could not of course win any regard from the scientific school in its struggle to attain absolute clearness, but indirectly it influenced the latter, inasmuch as the results of its practice showed the general significance of nature's tendency to cure. Dietl, one of the most important of Rokitansky's pupils, writes thus in the 'Zeitschrift der Gesellschaft der Aertzte' for 1845: 'Nature alone can cure; this is the highest law of practical medicine, and the one to which we must adhere even when we have discovered a principle of cure second to it.' 'Nature creates and maintains; she must therefore be also able to cure.'

Similar, however, was the watchword of that natural art of healing which became developed from Priessnitz, and which exaggerated all that was fantastical and imposing in his being,

although that in itself was not a little. And these were excesses which would have been almost comical had they not found in the trusting belief of the public ground for serious injury to many a constitution; for instance, the energetic thirst-cures of the peasant Schroth of Lindewiese, a village near Gräfenberg, who undertook to thoroughly dry-out such patients as had been inundated by his neighbour Priessnitz. A literature of the natural healing art arose, which seized upon the radical attacks made by leading medical authorities on legitimate therapeutics, in order to make use of them in a popular direction. Some of this literature proceeded from genuine physicians, and even if in it eccentricity and phraseology at first predominated and robbed it of a reputation in the scientific world, there was still no denying the important points of contact which united hydropathy with recent scientific medicine, and which came to the surface in the shape of more moderate and refined elements amongst the natural physicians. Both met halfway in their distrust of the old empirical drug-therapeutics, and endeavoured to replace it by physiological methods and dietetics, the importance of which was growing to be recognised more and more. Indeed, the recoil of scepticism upon the hydropaths is well shown by Stendel, who would only confess to 'water' in order to be able to persuade the patient that he was possessed of a positive therapeusis of any kind. On the other hand, more attention was being paid to dietetic rules and the mode of life regulated by natural laws of the hydropaths, according as confidence in the old *Thesaurus medicus* began to be shaken, although certainly only as hygienic and prophylactic measures. But the most important pharmacologist, by far, of modern times, Oesterlen, recognises in prophylaxis and hygiene the chief problems of practical medicine. In the preface to his 'Handbook of Materia Medica' he thus expresses himself: 'The educated and meditating physician of our century can scarcely any longer hope to obtain or accomplish by administering one or other of our useless stuffs that which only nature is capable of, if supported by all the natural aids of hygiene and dietetics. She alone will be able to yield the positive and really useful so long sought after and which materia medica never yet has yielded and never will yield.'

In the dietetic and prophylactic direction, therefore, the cold-water treatment was well provided for. Hippocrates had indeed already recognised and laid stress upon this application of it, but as soon as medicine had released itself from its self-imposed restrictions, and, standing upon the new ground of physiological research and experimental pathology, again displayed a tendency to energetic interference in diseased processes—the direction which it now took was such a one that, with the experiences which hydrotherapeutics had meanwhile undergone and utilised, it could not well refuse to lend a helping hand in elevating it to a prominent and permanent seat amongst the medical sciences. Just as in the Middle Ages the attention of meditative physicians was drawn by the healing springs to the actions of common water and there centred, and, as in the time when medicine consisted in dogmas, thermal culture led to hydropathy, so did scientific balneotherapeutics in modern times make the first move towards giving hydrotherapeutics a scientific treatment.

The literature of hydropathy as it existed at the time we speak of, was not a very rich one quantitatively speaking, but showed a greatly variegated character, from the most primitive—after the uncouth manner of Oertel and other lay publications void of any scientific contents—and from the hawkings of the numerous hydropathic establishments got up in order to benefit individuals, which only contained praises of one method or modification of a method, and sprang up like fungi after a shower of rain—to the thorough works of Hirschel, Mauthner, Fröhlich, Schnizlein, Plith, and others, which were pervaded by a scientific spirit. The combination of scientific physiology with the experiences of practical hydrotherapeutics met with in the works of these men, soon made its influence felt in other and different domains, more particularly on the closely related one of balneotherapeutics. The sprite of the springs had here held long enough possession, until at last he was exorcised by the triumphant advances of modern chemistry, notably by G. Struve. But the simple recognition of the constituents of the mineral springs did not satisfy the critical spirit of the time, which soon came to the conclusion that this was not a sufficient explanation of the many undeniable therapeutical actions of the springs.

Vogler of Ems first dared to utter the sentiment that this celebrated pneumic spring did not owe its efficacy to the alkaline carbonates it contained, but to the water as such, not forgetting however to give due credit to the influence of other hygienic agents, such as that of the air, the altered daily life, &c. Vogler's sober, physical method was soon adopted by the better hydrotherapeutists, and the 'hydropaths,' *à la* Oertel, vanished entirely from the stage, upon which scientific hydrotherapeutics now takes the stand to which it is justly entitled. Hallmann, in the preface to his work on the cold-water treatment of typhus, published in 1843, says truly: 'Thrice already has hydropathy offered its services to medicine. Currie announced the new study and gave it a capital recommendation; it was listened to by many, understood by a few, and finally—forgotten by all. No one attended to him when Hufeland, twenty years later, endeavoured to obtain it a hearing anew. Twenty years later still it again spoke, and this time in German, coarsely, by the mouth of a layman. . . . Hydropathy is no enemy of medicine; on the contrary, it prides itself on being a daughter of old Hippocratical medicine, and promises to be a powerful ally of its mother.'

IV. Scientific Hydrotherapeutics in Modern Times.

The stimulus to the recognition of the intimate connection between hydriatics and the study of heat-regulation, however, did not originate in Germany, but in France, where, about the end of the last century, the progress of practical medicine was most plainly visible in the splendid field surgeons she possessed, as might have been expected from the continuous wars she waged, and it was they also who advocated cold-water applications most favourably and zealously. Hydrotherapeutics, in the domain of internal medicine, was nearly forgotten; the works of the Italian, Giannini, excited some interest for a time, which, however, was not lasting. He was professor at Milan, and published a treatise in the year 1805 on fever ('Della Natura delle Febbri e del miglior metodo di curarle'), in which he takes up the cudgels in favour of the cold-water treatment of febrile diseases very energetically, falling back upon the experiences of the English hydriatic physicians, Currie, Wright, and Dalrymple.

It is true he substitutes baths of from 5 to 15 minutes' duration for the showers of Currie, and even though his theoretical views, influenced as they are by many humoro-pathological ideas such as the irritation-theory, render his system very artificial and complicated, yet on the other hand the simplicity of his treatment has rendered it possible for him to gather clear and reliable experiences. The rich material that lay under his hands of intermittent fever, have rendered the results he obtained in the treatment of that disease by baths valuable even to this day. Continued fever, under which heading he has ranged most of his typhus cases, is considered by him to be a lengthened paroxysm of the intermittent, and he treats it accordingly by cold baths, and most successfully too. He arrives at similar happy results in the treatment of acute rheumatism and gout, always—during or after the bath—using cinchona bark and tartar emetic as well. Inflammatory fever, however, he excludes from the cold-water treatment. His work winds up with the following fundamental rules:—

1. In considerable asthenia, short momentary immersions in cold water are indicated; in exhausted patients threatened by death, lukewarm water or simple ablutions should be used instead.

2. The submersion not to reach the cooling-down point, the first shiver being the sign that the bath should be left.

3. The temperature of the water is never to be artificially reduced by ice or snow.

4. During the general arterial orgasm, therefore, no submersion may be attempted (quite the contrary of what he gives for the treatment of intermittent fever).

5. The presence of the physician is absolutely necessary during the procedure (the danger of collapse was known to him).

6. In sensitive individuals it is necessary to apply warmth to the cardiac region during the cold-water procedure; in fact, it is indicated.

The renowned clinical physician Récamier adopted the cold-water method of Giannini, in conjunction with the cold showers of Currie for the treatment of the severest and most compli-

cated cases of acute exanthemata, protracted continued fever, and different forms of neuroses; but though the fame of his surprising results spread far and wide, his proceedings were looked upon as eccentric and daring, finding admirers it is true, but no imitators. The same thing happened to Foville, who recommended the cold showers against meningitis and encephalitis, for which he was severely censured by Calmeil.

The first attempt at a physiological explanation of the actions of cold water we find in Tanchou's little work, published in 1824, 'Du Froid et ses Applications dans les Maladies;' but even though his method of procedure found favour amongst the surgeons, it did not succeed in overcoming the prejudice which still existed in internal medicine against anything of the kind. Lacorbière, bringing out in 1839 a voluminous work entitled 'Traité du Froid,' Paris, had no better success. Notwithstanding that the work was elaborated with plenty of historical and physiological matter, it was still incapable of procuring general admission for hydrotherapeutics at a time when the fame of the immense successes of Priessnitz's establishment had already made its way to France. A small number of able scientific men, such as Engel, Wertheim, &c., devoted their energies to obtaining admittance for hydropathy; but in 1842 the Academy of Paris declared Priessnitz's method to be a dangerous one, and not sufficiently supported by experience. Luckily however, the few adherents were conscious of their object, and did not allow themselves to be frightened by this proceeding. The important Strasburg clinical physician, Professor Henry Scoutetten, travelled through Germany in 1843 by command of the war minister, Marshal Soult, in order to inspect the hydropathic establishments and become acquainted with their results, publishing his experiences in an official report of his travels ('Rapport sur l'Hydrothérapie,' &c., Paris, 1843), which was only the forerunner of a complete work, 'De l'Eau sous le rapport hygién. et méd.,' Paris and Strasburg, 1843. His concluding sentences run thus: 'Hydropathy cannot be reckoned an universal method; it exercises an undoubted influence on the public health, and the numerous permanent cures which it has wrought on intelligent and impartial persons recommend it to popular attention. It lies in the interests of

humanity and of medical science, that the demonstration of the forms and aids of hydropathy in Paris should take place under the eyes of able physicians.'

A short time after Scoutetten had recommended hydrotherapeutics, having tested it in its practical bearing, the classical investigations of Herpin into the actions of very cold river-baths were published in the 'Gaz. Méd. de Paris.' Herpin, a member of the board of health at Geneva, had carried out his observations on the Arve, a swift tributary of the Rhone partly fed by the draining away of the glaciers of Mont Blanc. Its waters had already been applied for healing purposes, having a temperature varying between 8° and 10° R., and the favourable results following their use had excited attention. Herpin instituted many series of physiological and therapeutical experiments, accurately noticing the pulse, respiration, blood-heat, and the bearing of the peripheral and central vessels, by which he arrived at very valuable conclusions, notably on the bearing of the cutaneous vessels and on the action of cooled blood upon the muscles. The therapeutical indications and contra-indications which he sets up are, theoretically as well as practically, more correctly based than was ever the case before his time. In a very moderate manner and with the cautious self-restraint of the practical physician, Legrand about the same time took the part of Priessnitz's method, whilst Wertheim, one of the busiest children's physicians, paved the way for hydrotherapeutics in pædiatric practice with successful energy. The hydropathic establishments which grew up in France, and certainly followed the Gräfenberg pattern at first, did not multiply as fast perhaps as in Germany, but instead they were withdrawn for the greater part from the hands of the laity in consequence of energetically handled medical legislation; and one of the first of them, Pont à Mousson, was under the direction of Lubanski, whose thorough and impartial observations elevate his writings to a place amongst the most important of those on hydriatics, more particularly the investigations into packing and the influence of cold-water drinking. In the latter the action upon the blood-temperature has not been noticed, it is true. Lubanski's investigations are penetrated by a chemical and physical spirit; he has succeeded in giving

a sober and correct explanation of the so-called critical exanthemata, and we also find that he was the first who undertook continuous examinations of the sweat and urine, although only in pathological cases. Robert Latour tested experimentally the elevation of the body-heat in inflammations, as well as the action of cold applications. The publications of these scientific French hydriatic physicians are plainly under the influence of the considerable experimental investigations which that genial physiologist, Magendie, had instituted into the heat-processes and cold applications. Simultaneously with Lubanski's publications appeared Schedel's book. Known by his dermatological writings especially, this man had kept himself aloof, and had nothing to do with a water-cure establishment whatever, but, led by scientific interest in the matter, he had gone to Germany in order to make studies on the water-cures. His book, distinguished for its impartiality, takes a true clinical standpoint, and compares medical therapeutics with hydriatics, giving the former the preference in a great number of cases particularly of acute diseases, and his representation of the evil after-effects of the drinking of cold water was clinically correct, and has remained invaluable. It was just this modest, temperate tone which gained such a rapid circulation for the book in medical circles. (More important still is his observation regarding the question—since then much ventilated—of the favourable influence of the cold-water treatment upon the consequences of incompetency of the cardiac valves.) Schedel is also the first physician by whom the agitation in favour of the hydriatic treatment of tubercular patients was started. Of this agitation the Liebenstein Congress of Hydriatic Physicians soon took advantage, and the further interesting development of this question extends into the present day. The first result it had in France was that the clinician Valleix corroborated the very favourable results obtained by some which he obtained in treating phthisical patients, who (against his own expectations) underwent without bad consequences the full cold-water treatment. Fleury, finally, who had made it his duty to introduce the hydriatic method into France since the year 1837, inaugurated a whole series of works by his memoir, laid before the Academy of France on the 7th of February, 1848, the aim

and object of them being to examine, physiologically and therapeutically, each hydriatic procedure. The first of these works was devoted to the douche and its application in intermittent fever, and in it he comes to the conclusion that the douche is a means whereby we can replace the use of quinia in the various forms of that fever; it was soon followed by a treatise which took up the subject of the douche and its astonishing successes in the treatment of pseudoanchyloses, as well as later on the treatment of chlorosis and scrofula by the same means.

Thus was the attention of the medical world drawn to hydrotherapeutics, and its influence on the therapeutic tendency was such, that although (as this shortly after became the case in Germany) the thermal moment was not considered exclusively indicative for this method of cure, yet the pathological alterations of the body-temperature received a larger amount of attention. In the spirit of these views laboured Monneret, who was sent to the East by the ministry to study cholera; but notwithstanding the great importance which he attaches to the observation of the body-temperature, he does not undertake its regulation beyond by means of shampooing and warm mustard baths. Others, however, were more courageous and successful, by deducting the practical results of his observations; and after the results became known which Reber, of St. Petersburg, obtained in the treatment of Asiatic cholera with cold water, numerous voices were raised in praise of this method, amongst others that of Blotin, who declared that he had already achieved, in 1832, the most favourable results from the administration of abundance of cold water combined with dry friction; also Burguières, who collected brilliant statistics of the method of Priessnitz, &c. The treatment of acute diseases by hydriatic methods was not confined to the cholera. An Antwerp physician, Van Housebronk ('De la Réfrigération Graduelle dans le Traitement des Maladies Aiguës,' Anvers, 1851), took up as his study, as did Fleury, the subject of the douche, another hydrotherapeutical speciality, namely, the gradual cooling-down of the body in acute diseases, and in his paper, distinguished by the Medical Association of Ghent, he records the splendid results for which he had to thank the hydriatic methods of varied local

packing, the methodical and accurate use of hip-baths and of affusion and shampooing. Thus he treated typhoid, puerperal processes, and, contrary to the restrictions observed by Herpin, inflammations.

The great value of hydriatic methods of procedure in surgical therapeutics was, since the time of Lombard and Percy, never entirely forgotten. The new basis which had been won for hydrotherapeutics principally by Lubanski's writings, was done full justice to by Gillebert d'Hercourt, who gives amongst others the wonderful results achieved by Bonnet by using the cold-water treatment against the relapses of cancerous tumours, an experience which Dumreicher corroborated later on. The great collective work of Fleury finally ('Traité Pratique et Raisonné d'Hydrothérapie,' Paris, 1852), in which he recounts the experiments which he performed on healthy people—experiments which had indeed been already undertaken and described by him, as well as by Howard Johnson, an Englishman ('Researches,' 1850), who did so in a very thorough manner—and models the practical results deduced from these into a system of hydropathy, appeared in 1852. Its author, like the thorough and scientific worker Lubanski, was director of a water-cure institution. These institutes had, taken altogether, increased in France and were placed in the hands of physicians only who were for the most part energetic men thoroughly imbued with the critical spirit of their times. A lay literature *à la* Oertel, as it appeared in Germany and bore such great fruit, was spared to France. Notwithstanding that this hindered on the one hand a rapid popularisation of the method of water-cure, and that we do not find in France a stream of pilgrims such as used to wander to the little Silesian village in the mountains in Germany, or to the numerous establishments fashioned more or less after the Priessnitzian method, it had on the other hand the undeniable advantage that unembarrassed medical research could employ itself more placidly with the question of cold-water treatment, and without being repelled by the aversion which the doings of the water fanatics and the blundering of 'Nature's physicians' called forth in Germany. In France, therefore, were also taken the first steps which led hydrotherapeutics into the wards of the university cliniques. In the year 1851 ('Union Méd.' 120) the

method recommended by Wanner (*q.v.*) for the treatment of enteric fever was tried on two patients at Andral's clinique, and afterwards by Briquet in five severe cases, whilst Leroy, in addition to blood-letting—which was still a favourite measure in France—tried gradual methodical cooling-down in the same disease and lost only five patients out of 139 thus treated, according to his own asseveration. Finally, the Englishman Armitage who had visited the German water-cure establishments, published in the 'Bulletin Thérapeutique' the results of the experiments with hydrotherapeutics in typhoid which he—in conjunction with Traube—had instituted at the Charité Hospital in Berlin, then under the direction of Schönlein. He (Armitage) used the cold showers according to Currie, as well as shallow baths of different temperatures and wet packing, and prescribed a combination of these methods according to definite indications. He is the first who gave out the dictum that the rise and fall of temperature was a much surer indication of the increase or diminution in disease than the difference in the pulse-frequency, and that every cooling process which brought about a palpable lowering of the temperature would also occasion a diminution of the pulse-rate and respirations. Of twelve patients thus treated eight recovered, whilst in the other wards of the same hospital the mortality from typhoid was seventy-five per cent.

This was the first important step towards the hydriatic treatment of typhoid as well as of acute diseases generally in Germany, and we may consider it as the commencement of the thermo-therapeutical tendency which soon became so influential. Not that other experiments had not preceded it; besides those already enumerated, there were many voices in favour of the application of Priessnitz's method in typhoid, which proceeded from the ranks of those physicians who had studied the method (Jürgensen). Hallmann, in 1844 and 1850, a deep-thinking, thoroughly scientifically-educated physician although with insufficient experience, takes his stand entirely upon Priessnitzian ground. In addition to the abstraction of heat, he sought to induce perspirations which he considered critical, by means of wet packing. The number of his cases is—three! One must confess that many of his views are in advance of his time; for example, he points out most particularly that, in the estimation of temperatures, a new and exact method of examination was

most desirable and important in regulating the water treatment; but such infinitesimal experience cannot remove a prejudice. Even poorer success had Scharlau (Stettin, 1853), who advanced the most untenable chemical theories. Whilst the method of treating acute diseases with water had thus entered upon a new and important epoch, a great movement was made to obtain for hydrotherapeutics a scientific basis by means of experimental research, to find out rational methods for the treatment of the chronic diseases, and to prove them practically.

The method of testing the influence of the various internal and external applications of water upon the circulation, temperature, and tissue-metamorphosis of healthy persons was adopted by German investigators, and gave valuable results worthy of their industry and thoroughness. This was the method followed with success by Lubanski, and later on still further developed by Gully and Howard Johnson. Thus Falck took up the questions concerning the internal use of water, the action of water-clysters and of absorption by the skin in the bath; Petri took up the sweating method of Priessnitz, the cold sheet and the sitz-bath, at the same time giving copious special therapeutical indications, of which we need only mention those for the treatment of syphilis for example. Preiss introduced a new and potent method of application in the occipital douche, which he used against nervous asthma. Böcker, of Bonn, contributed most complete experimental investigations into the tissue-metabolism and its behaviour during the internal administration of water as well as under its withdrawal, both with and without the addition of dry food. These investigations, coupled with those of Genth, of Wiesbaden, led amongst other things to the law—since then undisputed—that the excretion of urea increased during the copious administration of water, whilst the formation of uric acid is diminished and the chlorides and phosphates undergo a proportionate diminution as well. The influence of the individual hydriatic procedures upon the tissue-change was gone into by Wundt, and special hydriatic therapeutics were enriched by Fischhof, of Lunkany (Hungary), who obtained very good results in the treatment of intermittent fever, especially with sitz-baths (Fleury having recommended the douche).

The cold-water treatment of cholera, as it had been already

instituted by Monneret, was elaborated by Pfeufer, Richter, Schildbach, and others.

The question of the treatment of the insane was actively ventilated (Erlenmayer, Petri, Scharlau); many specialistic works treated of the position which hydrotherapeutics held in gynæcological, dermatological, and pædiatric practice. In answer to a question given out for a prize essay by the Paris Academy, Poulet published a series of genial experiments and deductions drawn therefrom, their object being to quash the assumption that absorption took place by the skin, and on the same subject Eichberg, at Vierordt's suggestion, undertook a series of experiments at the Physiological Institute at Tübingen, for which he chose the elbow-bath, and he succeeded not alone in proving absorption—though only very slightly—but was even able to lay down laws for its measurement. We meet in Mosler's very comprehensive prize essay on the physiological influence of the internal administration of water, the first exact quantitative experiments on the excretion of carbonic acid, and beside it appeared the important collective works of Richter, Scharlau, and others, who treated hydrotherapeutics conscientiously and in a most detailed manner from a strictly clinical point of view.

In a word, the question of hydrotherapeutics, although still one of the numerous hobbies of 'Nature's physicians,' had blossomed into full scientific estimation, and had mastered its place in medical practice when an important turn took place in pathological views.

In the first volume of his 'Specielle Pathologie und Therapie,' Virchow shows the elevation of temperature to be the pathognomonic symptom of fever, and to be occasioned by an increased change in the constituents of the body, the latter, however, being due to paralysis of the heat-regulating nervous centre owing to the fever irritant. Thermometric measurements, carried out with increasing exactitude and conscientiousness at the different cliniques and in the most varied forms of febrile disease, supported this view; for example, the measurements taken by Smoler, of Prague, of typhoid patients with pneumonia, pleurisy and peritonitis. The antiquated teleological view which considered fever to be a curative process (Heilfieber), received its death-blow through this transforma-

tion of the theory of fever, and the energetic lowering of the fever had now to be recognised as the most important problem.

Elevation of temperature once recognised as the pathognomonic symptom of fever, means were immediately sought after which should cause a constant and material decrease of temperature. The great exactitude with which it is able to prove an actual lowering of temperature—thanks to the advance in thermometry—the application of the empirical statistic method, and the harmony which existed between its results and pathological deductions, assured this therapeutical tendency a great interest.

Wunderlich's 'Archiv,' organised in 1858, headed the column, and from the Leipzig clinique emanated statistical investigations which soon led to important results in a diagnostic direction, for it was found that the body temperature in a portion of the acute febrile diseases, particularly in the infectious fevers, followed a typical definite course, which is often a useful aid in the more exact determination of the nature of the disease, and in any case furnishes exact numeral expressions of the fluctuations in the progress of the disease. Wunderlich used this diagnostic thermometry as the direct supporter of therapeutics, attaching greatest weight to fever therapeusis; and, whilst he agitated against the purely local treatment of the exclusively pathologico-anatomical tendency, he points out that the most powerful means of acting upon local processes is by acting upon the general condition (Petersen).

Following on the approval which this view met with in a very extended measure, came the problem to which therapeutical activity now devoted itself, namely, to find antipyretic remedies or—which was equivalent to Wunderlich—antifebrile remedies.

Tidd, of London, had recommended alcohol (cognac) as a fever remedy of universal action, which he gave in inflammatory diseases as well as in typhus and malarial fever; a method which had numerous followers in England and France, but very few in Germany, although it was there tested as to its temperature-lowering properties. Vogt, of Berne, returning to Sydenham's principles in combating fever without having regard to its localisation or quality, recognised the task of therapeutics

in typhoid and inflammation of the lungs, and contributed rich and very favourable statistics of the veratrine treatment. As the treatment became more general, however, it was found that the fall of temperature caused by this method was only too often accompanied by attacks of collapse of the most serious character, and the remedy soon fell into as much disrepute as the 'antipyreticum *par excellence*' of Wunderlich—digitalis. The abortive treatment of typhus by large doses of quinine, introduced also by Vogt, maintained itself a little longer; following him came Wachsmuth, who proclaimed the remarkable antipyretic actions of large doses of quinine in typhus and typhoid fever in 1863. Whether quinine was merely an antipyretic remedy or a really antifebrile one always remained an open question; the attempt to answer it by way of contemporaneous temperature measurements and experiments on tissue-change led to no decisive results. It was not alone uncertain in its action, but its maximum effect, a fall in temperature of any significance, is only attained by giving a dose which calls forth true phenomena of intoxication, the serious character of which is, however, not to be compared with that of the phenomena appearing in the course of the veratrine and digitalis therapeutics. An antipyresis without danger of intoxication was the ideal floating before the eyes of fever therapeutists, and the only means of obtaining this lay in the cold-water treatment. The works of the last decades had tested it physiologically and clinically, and completed the details of its method of application sufficiently to give the physician a remedy with which he might combat fever through the circulation as well as through the nervous system, and with which no other can be compared for its power of being regulated. Von der Decken-Himmelreich's capital study, which appeared in the year 1858, found little or no accord in literature, although it gave all *in nuce* that later investigations taught in the treatment of febrile diseases with cold water. Brand, of Stettin, published in 1861 the details of a somewhat complicated water-cure method in typhoid, the chief factors in which were baths of from 10° to 20° C. (50° to 68° F.) and compresses; his results were very favourable, and won for him many imitators, but to Bartel's clinique, at Kiel, certainly belongs

the honour of having obtained for the antipyretic cold-water treatment the right of citizenship in science, inasmuch as it proved by means of extraordinarily exact thermometry the undoubted cooling action which water possesses, at least in typhoid fever. Jürgensen's clinical studies, published in 1866, created almost an epoch in medicine, for they not alone proved that the cold-water treatment (reverting to Currie, he used principally the douche) lowers the body temperature and diminishes the grave symptoms, but also a lessening in the rate of mortality, and made the shortening of the course of the disease more than a probability. In the meantime much had been done in the study of the tissue changes as the chemico-physiological methods became more complete, and also in the knowledge of the conditions of temperature in the healthy and diseased organism, as well as of the relations which exist between these and hydriatic procedures. Beneke, of Marburg, had already, in 1855, made the sea-bath the subject of his studies, and thoroughly tested its influence on the metabolism of the tissues; Virchow extended these investigations to the alterations in the pulse, respiration, and body temperature, and his results are so much the more important for hydriatics inasmuch as his view of a sea-bath is, that it is a cold bath first of all. The important *rôle* which the nervous system sustains in the regulation of heat was done full justice to by Preiss, of Berlin, who in 1858 investigated the physiological effects of full baths. The study of heat regulation was indeed becoming more and more clear through the physiological experiments of Hoppe, Valentin, and others, in addition to the experiments of Gillebert d'Hercourt on the influence of cold applications—made more with regard to their therapeutical usage—and those of Mantegazza on the internal use of warm water. The applicability of hydriatic procedures to certain diseases and groups of diseases, was at the same time proved systematically. Fleury, for instance, succeeded in obtaining the treatment of the phthisical patients in Andral's clinique, and under Becquerel's supervision the results which he obtained were of such a nature that the clinician Tartivel announced hydriatic treatment to be useful in every stage of tuberculosis.

In Germany these experiences were soon recognised to the

fullest extent, and, in combination with the therapeutics of climate and elevation (Lersch, Rohden and others), which had in the meantime got into full swing, were applied with unheard-of success. Richter formulated a special hydrotherapeusis of abdominal affections as well as of acute affections of the organs of respiration; he finds, that the action of cold-water applications in pneumonia lies in the restoration of the suspended inhibitory function of the vagus, i.e. in slowing of the increased cardiac action. The great Würzburg gynæcologist Scanzoni, recognised and made use of the wholesome effects of hydriatic procedures in hysterical nervous affections; and a luminary of the Vienna Clinique, Professor Dumreicher, in the report of the meetings of the 'Gesellschaft d. Aerzte,' speaks reservedly, yet upon grounds of practical experience, in favour of the usefulness of hydriatic procedures against the recurrence of operated carcinomata.

The influence of the water cure on mental diseases had raised a lively controversy; its injuriousness was empirically proved in some cases. Richter threw light upon this difficult question, and detailed the precautions necessary in the treatment of mental diseases. Claude Bernard's important discoveries in the origin, course, and action of the vasomotor nerves were most useful to the procedure of temperature modification, which hydrotherapeutics was now universally recognised to be. Chapman ('Medical Times,' July 18, 1863) founded the application of his spinal ice bags upon the law that paralysis of the sympathetic nerves brought on dilatation of the vessels they supply, and consequently peripheral hyperæmia with relative increase of temperature; whilst irritation of the sympathetic ganglia brought about contraction of the vessels, and consequently anæmia and lowering of temperature. These bags, alternately filled with ice and water, were applied to different parts for a variable length of time, so as to have upon the local circulation either a stimulating, soothing, depressing, or paralysing effect. They soon became a valuable assistance, especially in spinal and nervous diseases.

In Vienna active and sympathetic attention had meanwhile been directed to the progress of the water-cure method. In the year 1836 there had already emanated thence that thoroughly

scientific illumination of hydropathy by Hirschel, as well as the searching works of Fröhlich, Mauthner, Plith, and many others. Here also appeared, in 1864, Pleninger's work, 'The Physiology of the Method of Cure by Water,' which, embracing the experiments of modern times, more particularly deals with the theoretical side of hydriatics. In 1866 Friedmann and Rosenthal published valuable experimental and clinical contributions to the question of the hydriatic treatment of nervous diseases. In the same spirit Winternitz, at Vienna, in 1856 subjected the question of the local application of cold to a most searching investigation, and pointed out what was improper in the previous method of applying it. For his investigations he used the sphygmograph, invented by Marey, with which he examined the bearing of the vessels during the application of snow and ice to different parts of the body, especially the behaviour of the radial pulse in the elbow bath, which caused a contraction of the artery and a fall in the temperature of the palm of the hand. He thus succeeded in ascertaining the varied behaviour of parts centrally situated; and the application of ice or freezing mixtures between the centre and the diseased periphery as introduced by him, became of prominent value in the treatment of hæmorrhages, aneurisms, and local inflammatory processes. Three years later the revulsionary action of thermal cutaneous irritation underwent a similar examination at his hands. Temperature measurements taken in the external auditory meatus showed him a decrease in heat during cold foot baths, and he explains the action of general revulsionary procedures by the determination of blood to the dermal organ, comparing the process to the Goltzian tapping experiment. He likewise studied the action of local procedures upon the respiratory centres, and in this direction precisionised the application of the *douche filiforme* according to Mathieu, of the shower bath, hand bath, &c. The vapour bath, which in its form of a general or Turkish bath had already furnished the materials for a copious literature, was by him converted into a box vapour bath, suitable for local purposes. The value of hydrotherapeutics in acute diseases and in intermittent fever, received a new and interesting enlightenment at Winternitz's hands, inasmuch as he proved that the influence

which cold-water procedures exercised upon the nervous system as stimuli was much more important than the merely physical action of the deprivation of heat, and he tried to study and make use of this influence. When we add that the influence of methodical cold-water drinking was also investigated by him, in every direction and most thoroughly, we need not wonder that, through the manifold, indefatigable, and original labours of this investigator, Vienna from that time became the centre of activity in hydriatics, just as Kiel was for the water treatment of typhoid, and Leipzig for pathological thermometry. The latter had advanced steadily, and physiological investigation untiringly went on throwing light upon the various heat processes in the organism. Eulenburg showed the lessening of activity in the sensory nerves under the application of cold; Cyon (in Ludwig's laboratory at Leipzig, 1866) studied the influence of temperature upon the heart's action; Cohnheim undertook his wonderful experiments on the influence of cold applications to the rabbit's ear, and Otto Weeber upon the generation of heat in inflamed parts. In Fick's laboratory at Zürich the relations of the muscular system and skin to heat production and regulation were zealously studied; Schmulevitsch in 1867 investigated the influence of temperature upon the frog's muscles; Schiffer and Fick himself measured the amount of heat produced in working and resting muscle (1865); whilst Laschkiewitsch proved that the deadly phenomena following the application of a coat of varnish to the skin were not due, as had been the idea, to asphyxia in consequence of the suspension of the respiratory function of that organ, but to cooling through paralytic dilatation of the cutaneous vessels. Krieger on the other hand ('Zeitschrift für Biologie,' v.), in a work on the origin of inflammatory and febrile diseases, attributes these phenomena to lessened heat production, seeking to prove that the causes of the diseases named consist in disturbances of the general or local heat economy, and in saturation of the body or of individual tissues with water; and in favour of this view he endeavours to bring physico-mathematical proof. The retention of water was substantiated experimentally by Naunyn and Leyden. Jacobsen and Landoe showed by division of the sympathetic nerve, its influence upon local heat regulation.

Jürgensen's work above-mentioned and published in 1866, was of epochal importance to the treatment of acute febrile diseases. Von Wahl in St. Petersburg showed that the laws of heat regulation in a fevered organism underwent considerable modifications, and introduced the important conception of the accumulation of heat into the theory of fever. Temperature measurements had been already taken per rectum and vaginam since the time of Güterbock and Charcot, and thereby gained considerably in reliability. In 1868 appeared Wunderlich's work on thermometry, of the contents of which we have previously made mention. In the 'Zeitschrift für Biologie,' the question of heat regulation and of fever was treated just as energetically from the chemical side as it was from the physiological in Pflüger's 'Archiv.' The ideal lowering of temperature in fever as Jürgensen wanted it, had to contend with the objection that every cooling of the body was followed by greater heat production and therefore increased destruction of albumen, the consumption being thus raised. Jürgensen had met this objection experimentally himself, but it lost its ground altogether when Pflüger and Voit's investigations proved that the source of heat did not consist in the metabolism of the albuminous bodies, but in the non-nitrogenous combinations. The works of Leyden ('Archiv f. klin. Medicin,' v.), Naunyn ('Archiv f. Anat. u. Physiol.'), and Senator were conclusive on this question. Leyden instituted series of calorimetrical examinations on fever patients and healthy persons, at the same time taking the body weight, and proved in fever and its declining stage the increased giving-off of heat and increased heat production with simultaneous water retention; he also sought for and found almost exact figures for the dangers of consumption and inanition in fever. Chemical examinations undertaken at the same time proved to him that a retention of products of incomplete oxidation also takes place in the tissues in fever.

Senator places the assumption of a self-regulation of heat within its own very narrow limits, as did also Voit later on. Senator, as well as Murry, established conclusively that in the cold bath the amount of heat given off exceeds the amount produced, that therefore a real cooling-down in fever is

attainable, and that even without increasing the consumption. The ranges of normal heat production were fixed by him, and he confines them a good deal closer than had, up to date, been the case. His experiments are quite decisive for his acute manner of proving things, and were carried out on dogs which he put into a febrile condition by means of injecting pus. He estimates, in addition to the weight (and temperature), the amount of the urea excreted by these dogs, and calculates—it is true, with an error afterwards corrected by Breuer, but which does not injure the weight of the proof in the slightest—the amount of water and carbonic acid excretion ; and since he finds (like Naunyn) only the nitrogenous metabolism increased, he concludes that it is not the production of heat at all which undergoes any appreciable increase in fever, but that the elevation of temperature has its principal cause in temporary arrest of the radiation of heat. This assumption had been already held by Traube, and Winternitz, by measuring the amount of heat given off by the skin with an apparatus invented by him, brought direct proofs to support it.

The last scruples which still stood in the way of the cold-water treatment of acute diseases, fell universally when this new theory of fever, which received such substantial corroboration on all sides by the experiences of medical empiricism, was brought upon the scene. The cold-water treatment of typhoid took a permanent position in all German hospitals. At the meeting of natural scientists held at Innsbruck, Drasche placed the brilliant results which he had obtained with it at the Viennese Rudolf's Hospital before the meeting, and on all sides similar results were reported. The point at which the treatment of acute febrile diseases should begin was arrived at by the temperature and its condition, and the comfortless abstinence of the expectant treatment had to make room for active interference in the thermal processes of the organism—the strongest therapeutical remedies from digitalis to quinine, from veratria to salicylic acid, being unable to cope with the competition which the hydriatic procedures ran them into, or at least they could not do without their assistance. The difference in the forms of application did not in the slightest degree alter this state of affairs; for Jürgensen used baths of 10° C. (50° F.), whilst Brand

preferred them at 23° C. (73·4° F.) Fiedler and Hartenstein, Riegel and Rosenberg studied the difference in the physiological effect of both these, and thereby arrived at the interesting knowledge of the difference between the course of the temperatures measured in the axilla and those taken in the rectum. But still the fear was now and again expressed that the withdrawal of heat would cause a greater heat production, and, as a consequence thereof, heighten the consumption. This fear must have had its origin in the mystical high opinion in which the heat-regulating operations were held; to allay it, the laboratory of Pettenkofer and Voit at Munich took particular trouble. Klug ('Zeitschrift f. Biol.' x.) showed of how little use was the heat production of the body against low temperatures without the artificial aid of clothing. 'By his clothing,' according to Pettenkofer, 'man is placed in a condition equivalent to his moving about naked in a temperature of 24° to 30° C.' (75·2° to 86° F.) The experiments finally of Voit caused the last fears to vanish. The apparently contradictory experimental results of Colosanti and Pflüger were brought into perfect harmony by the subsequent discovery of Winternitz, that the reflex increase of the heat production did not depend upon the absolute amount of heat withdrawn, but upon the measure of the thermal nervous stimulation.

The activity of scientific labour in hydrotherapeutics showed itself not alone in its extension to different pathological methods, but also in the invention of new technical methods and in the elaboration of the existing ones. The combination of hydrotherapeutics with the dietetic and gymnastic methods, as also with elevation therapeusis, attained considerable practical results.

The acute exanthemata (Hunter, König, Baginsky, Nissen, Baum, and others), acute rheumatism, the exudative processes, &c., furnished very favourable statistical results for the hydriatic treatment; the literature of the cold-water treatment of phthisis (itself a very copious one) had a long list of favourable results to show, and the hydriatic or combined treatment of this affection gained for itself enthusiastic followers throughout the whole of Europe and outside of it. We need only mention here the names of Williams, Souplet, Sokolowsky, and Gubler.

In midwifery practice (Osterloh, Garvin, Munk, and others), as well as in that of pædiatrics (Stössl, &c.), hydriatics played an important part. Hydrotherapeutics was applied by Beni-Barde to the treatment of Addison's disease; numerous French writers, such as Hirtz, Sivermann, and others, corroborated what Winternitz had reported concerning the soothing effects of hydrotherapeutics in heart affections and psychoses. The method of procedure was materially improved, especially by Kemperdick's invention of the cooling sound—by means of which it is possible to make a direct impression upon the intestinal temperature—by the combined methods introduced by Winternitz, by the divided water cushions, and lastly, the invention of the psychrophore and other cooling apparatus by the same investigator. It is of course quite natural, that with this increasing importance of hydrotherapeutics in the scientific department as well as in that of practical therapeutics, should be combined the more general application of water in the hygiene of daily life. So much the more conspicuous became one voice which vociferated loudly against the use of baths and water applications at all, and this was no less a one than that of the famous dermatologist Professor Hebra, of Vienna, who had himself enriched the treasury of hydriatics by his invention, in 1862, of the continuous water-bath (water-bed). His reasons for this opposition to 'aquatic sports' consisted in the maceration of the skin and the diseases consequent upon it (the abdominal-bandage disease), but he reserved a whole group of skin affections for the continuous water-bath, foremost amongst which are burns. The bizarre but good-humoured denunciation was at once quietly but efficiently refuted by Pleninger and Winternitz. Similarly were the fears which had been expressed on different sides concerning the cold-water treatment of typhoid—especially that fear which ascribed to it the occurrence of intestinal hæmorrhages—allayed by Goltdammer and others, by means of eloquent figures. Compendiums of hydropathy which now appeared, were those of Fleury, Beni-Barde, Pleninger, Pinoff, Cervinski, and others.

In 1876 appeared the first volume of Winternitz's 'Hydrotherapeutics on a Physiological and Clinical Basis,' which described the influence of hydrotherapeutics on the circulation

and innervation in a series of twelve lectures. This was the first attempt at a critical collection and analysis of the whole previous results, and it happened to appear at an exciting period. The fever question had not become any clearer through the renewed controversy between Senator and Pflüger, the mechanical heat theory had been introduced into physiology with beneficial effect by Fick's examinations into the processes which the temperature of working muscles underwent, and in accordance with the theories established by Winternitz were Voit's investigations, showing the importance of nervous stimulation in heat regulation. Then appeared Winternitz's book, and brought up a host of personal experiences such as can only be at the disposal of the director of one of the largest establishments; also originally devised experiments amongst them, e.g. the plethysmographical proof of the increase in volume of a part of the body not in contact by the influence of cold at a distance, in addition to much sphygmographical material. As might have been supposed, this work created a great sensation and the Canstatt annual report declared that by it the cold-water treatment had obtained great extension, inasmuch as it showed—at the bedside as well as at the experimenting table—that the treatment could be useful in almost every disease. With Winternitz's compendium, finished in 1879, we find the present point at which the study of hydrotherapeutics had arrived written in heavy black type, and its place in the medicine of the day characterised therewith. As in no other branch of medical activity, we find here a method whose advances have been individually and physiologically tested, and have been adapted to the laws of the living organism, to be converted into a rational curative measure for special purposes of application, whose therapeutical results are the more reliable since they have been often corroborated by empiricism prompted by a spirit of impartial and fruitful research.

That which medicine of the 19th century has struggled to attain since it awoke from the desperate period of absolute scepticism—namely, practical, prophylactic, and therapeutical action, based upon the results of theoretical research in its whole extent, thereby being in a position to give to the prac-

tical physician that security of which the physicist or chemist boasts—all this hydrotherapeutics is on the way to accomplish.

The treatment of the acute febrile diseases, especially of typhoid and of the exanthemata, is at present in the large hospitals of Germany carried on upon the principles of scientific hydrotherapeutics. In the treatment of inflammatory affections and acute rheumatism hydrotherapeutics has not succeeded in establishing its footing at the cliniques of Germany; in England and France, however, this has been already the case (Wilson Fox). The psychiatrists still raise strong objections to the adoption of any hydriatic procedures in their department, although some of the younger ones, e.g. Erlenmaier and Schwarzer, recognise their benefit and applicability in various psychoses. To no physician does it now occur to deny the great successes of the cold-water treatment in chronic local and general affections, especially metabolic disturbances; its rational foundation, also, is no longer doubted. When, in spite of this, we find that the application of hydriatic methods of cure is confined almost entirely to the certainly numerous, and for the most part scientifically conducted hydriatic institutions, the only explanation we can offer is, that the knowledge of the special hydriatic methods still requires considerable dissemination amongst physicians. In France, P. Delmas published in 1878 a valuable work full of rich physiological and clinical material which he collected at the hydrotherapeutical clinique of the Bordeaux Hospital.

That which Germany possesses in this domain at Leipzig and more lately Vienna, is only a beginning; but the ground in which it is rooted has been tilled by true scientific labour, and a ripe and plentiful harvest is assured it thereby.

SECOND SECTION.

MODUS OPERANDI OF THERMAL AND MECHANICAL INFLUENCES UPON THE ORGANISM.

THE PHYSIOLOGICAL FOUNDATION OF HYDROTHERAPEUTICS.

THE MODUS OPERANDI OF WATER UPON THE ORGANISM.

It will here be our endeavour to show in what manner the thermal, mechanical and chemical influences which constitute hydrotherapeutics act upon the organism. We shall endeavour to show how and what functions are influenced by the said factors, and it will be our task to deduce therefrom what hygienic, prophylactic, and therapeutical problems this method, either alone or supported by other agencies, ought to be able to solve.

Common water brings about alterations in the living animal organism, firstly, by its temperature; secondly, by its aggregate form (mechanical actions); and thirdly, by actions dependent upon its chemical constitution.

1. ACTIONS OF TEMPERATURE.

Different temperatures cause alterations in all organic life, from the simplest protoplasm to the most highly developed organism. These influences, as stimulants to motion, are best followed in the lowest organic objects of observation, namely, corpuscles of protoplasm. We here observe, under the microscope, how ciliary motion is promoted by warmth, lessened and suspended by heat, promoted again by gradual cooling down, and finally ended by cold. The simple cell, the blood corpuscle, smooth muscular fibre and animal muscle all display

increased or lessened motion upon thermal and, as I may here at once add, upon mechanical influences being brought to bear upon them. Common water, as the vehicle of a definite temperature, acts also upon more highly developed, living, warm-blooded organisms, and brings about changes which manifest themselves (*a*) by stimulation and (*b*) by influence upon the temperature.

(*A*) *STIMULANT ACTIONS OF DIFFERENT TEMPERATURES.*[1]

The first effect of cold and heat upon the body is a stimulant one. The irritation will be the more powerful the greater the difference in temperature between the body and the operating medium, independently of the simultaneous mechanical influence, which is also of importance to the degree of the stimulation, as we shall presently see. Differences of temperature amounting to only a few degrees will not produce any very remarkable phenomena, since they approach too closely the neutral point at which the temperature of the body and that of the influencing medium are the same. In this case almost the only action which will be perceptible, can be obtained by contact with a medium of different physical properties—i.e. mechanical action. Taking into consideration the circumstance that our nervous tension is almost entirely dependent upon the impulses conducted to the central organ by the peripheral sensory end organs, we can produce, by means of temperatures which are close upon the point of indifference, alterations in innervation, changes in the tension, &c. These are actions which are principally manifested by keeping off stimulation, and they are therefore called upon to perform an important therapeutical part, especially in cases of very great irritability and excitability.

'Very seductive is the explanation of Heymann[2] for the actions in question of such baths as approach the point of indifference in their temperature. Heymann and Krebs, of Wiesbaden, sought to establish of what quality a fluid must be in order to be able to place

[1] In this I adhere to the illustration of the stimulant action of different temperatures given in my *Hydrotherapeutics on a Physiological and Clinical Basis.*

[2] 'Investigations into the Actions of River Baths and of various other Baths, *Virchow's Archiv*, vol. 50, part i.

the cutaneous nerves in a state of rest or of excitement. According to them, the peripheral endings of the sensory nerves are the probable mediums of rest or excitement. They measure the soothing or exciting action, according to the method of Scoutetten, by the magnitude of the nervous current excited by the contact of the water with the skin. The said authors explain the soothing as caused principally by soaking of the peripheral nerve endings, whereby the excitement of the latter can be reduced almost to complete extinction. Numerous physiological facts are brought up which are to support the view that by deprivation of water the nerves are excited, whilst water taken up slowly diminishes irritability. A bath at the temperature of the surface of the body is capable of placing the nerves in the condition of saturation even without any absorption of water taking place by the skin. This occurs still more easily by saturating the epidermis with fluid if possible. The end bulbs of Krause of the sensory nerves and the touch corpuscles of Meissner are able to take up water by way of endosmosis; but the peripheral nerve endings are richer in water after a lukewarm bath, even though no absorption take place by the skin, because insensible perspiration ceases whilst in this bath and there is no secretion of sweat. The excretion of fluid by the skin is restrained during the bath; all baths however, in which the electrical current generated by contact with the body exceeds the amount of soaking, are supposed to excite; baths in which the saturation exceeds the current, to soothe. If, therefore, our common sensation is so obviously dependent upon the condition of the peripheral sensory nerve endings, may not, analogous to Pflüger's law of the avalanche-like advance of excitement, also every excitement of the cutaneous nerves be carried up to the brain in like manner? A suspension of molecular motion caused by soaking, as in the lukewarm bath, can give rise to a general calming down of the nervous system. Examples of such a narcosis caused by soaking of the peripheral nerve endings are, the disappearance of itching in the luke-warm bath, diminution of cutaneous sensibility whilst in the same, disappearance of the feeling of fatigue, and the relief of forms of spasm. A cessation of cerebral disturbances might likewise be caused by the induction of sweating, partly through saturation of the cutaneous nerves from within outwards, and in part also through evaporation, which reduces the blood temperature. Irritation and soothing of the peripheral nerves are conveyed with rapid increase to the brain.'

Cold and heat also are perceived by the nervous system, like the electrical current, as specific hot and cold impressions.

Only excessively low and high temperatures are not perceived as cold or heat but as pain, until finally the irritability, sensibility to stimulation, and function of conduction in the nerves are lowered or even totally suspended.

There are innumerable proofs, *direct and indirect*, which can be adduced to show that it is really the nervous system and innervation which are influenced by low and high temperatures. 'For example, I will refer to the quick restorative powers of cold and cool momentary baths, showers, ablutions, and immersions for the fatigued and exhausted; to the feeling of comfort, the exhilaration, which follows each cold ablution in conditions of depression; the rapid reanimation of faint persons by simply sprinkling them with a few drops of cold water; the nerve-stimulant and rousing actions of dashing cold water on persons in conditions of sopor and coma; the often momentarily successful relaxation of severe forms of spasm; the frequent, albeit only passive, beneficial action in the paralysed; the well-known attempts to rouse the apparently dead by means of drops of hot sealing-wax; the sudden alteration in the frequency and depth of the respirations and of the circulation under impressions of cold and heat—all may be taken as striking proofs that different temperatures operate as nerve stimulants and as nerve stimulants of powerful, prompt, and often infallible efficacy. That thermally depressive effects can also be obtained, and that we are in a position to lessen and altogether suspend conduction in the nervous system—this is proved by the invariable relief of often the most intense pain by means of very cold or hot applications. This proves the possibility of local anæsthesia being attainable by the same means which, when carried to excess, are capable of producing local and general destruction of sensibility to irritation, or may lead to local or general death. Too great cold or too great heat destroy the sensibility of the nerves to stimulation in like manner as too glaring light blinds and causes paralysis of the retina.' The sense of touch likewise becomes confused by too high and too low temperatures. The action of very great cold on the trunk of a nerve has an anæsthetic or paralysing effect upon the peripheral distribution of the said nerve. For instance, it is possible to put the hand and fingers to sleep by means of

high and low temperatures which are allowed to operate upon the elbow joint or ulnar nerve, to lower the acuteness of the sense of touch and feeling of temperature, and also to diminish and destroy the mobility of these parts. The heightening of the irritability (proved by Rumpf, Schiff, and lately by Friedmann) of the nerves in a symmetrical part of the body upon the unilateral application of stimulant temperatures, the demonstration of transference under such influences, and the swaying to and fro of the irritability are all phenomena which show us the power which temperature influences possess over the nervous system, and allow us to recognise the therapeutical significance of such influences.

The views of authors are, it is true, still very divided as to the theory in what way thermal irritation is perceived by the nervous system. Some maintain that the contact of different temperatures generates an electrical current which passes from the warmer over to the colder medium. Heat and cold operating from the periphery will, according to this, generate either an ascending or a descending electrical current, either strengthen or weaken the normal nerve current—proved to exist by Dubois—and be perceived by conduction of the altered strength of the current to the centre, whence it is transferred to motor fibres. Heat and cold would therefore serve as incitements to motor and sensory tracks, and even be capable of producing in the central organ actions of altered function and alterations in innervation. By taking this view of the matter, it is possible to explain how it is that many phenomena which appear under electrical operations are also observed under thermal influences.

The mechanical theory explains these latter phenomena by the changes in volume which cold and heat produce within the molecules concerned. This change in volume necessitates a change of position, a movement of the molecules, under a rapid impression of very different temperatures—especially when supported by corresponding mechanical interference—even a regular concussion, which may make its way to the centres, and from thence pass on to the motor fibres. It is probably more than mere imagination if one fancies at such a time that every nerve stimulation acts like a shock. The view of Fleischl,

that the axis cylinder in living nerves has a fluid consistency—a view at which Rudanofsky had arrived previously—allows the physical possibility of a mechanical continuation of the thermal contracting or relaxing impulses from the peripheral end organs to the centre. The effect produced by heat and cold—that is, therefore, either by excitation of electrical currents or by mechanical contraction or distension of the molecules of the peripheral nerve endings, perhaps even by both these influences together—will make itself felt at the point of contact, in centripetal sensory tracks leading thence, and in the central organ itself, and is thence conducted centrifugally on motor tracks. The thermal stimulation will in this wise cause alterations of innervation at the point of contact, in the sensory tracks on the central organ, and in all motor and trophic fibres in relation therewith, as soon as they are placed within the region of stimulation by means of conduction or reflexion. But this impression on motor fibres is not to be considered as a reflected one alone, since there are also found at the point of application numerous ganglion plexuses, and the assumption lies very near that these ganglia might act just like so many peripheral centres which, upon direct stimulation, could influence the formations governed by them without requiring a higher impulse from the brain or spinal cord. Many stimulant effects which used to be looked upon as reflected ones might therefore occur upon the local irritation alone, and without the participation of the nervous central organs.

The thermal stimulation will be seen to not alone heighten innervation, as every other nerve stimulation will do—i.e. to act directly stimulant—but we will also be able to produce exactly opposite effects with the same stimulating agent—in fact, *to diminish the irritability, tone down the innervation and even to paralyse it.* Thermal stimulation makes itself felt, therefore, by phenomena of depression and of excitement. That these phenomena must really be construed as stimulant and hyperstimulant actions upon the nerves and the central organ, is also further shown by the fact that they follow the impressions immediately—very often with lightning speed—before the different temperatures brought into contact could possibly be equalised. It is also hardly imaginable that the deprivation

of heat itself—the reduction of temperature—can be the original cause of the nerve stimulation, since blood with reduced heat loses its capability of stimulating the nerves. *A nervous excitement* as it appears *after considerable losses of heat*, is, as we shall see, a consequence of heat deprivation, a so-called reactionary phenomenon. On the other hand, the supplying of heat and elevation of the temperature of the blood and tissues thereby are more capable of calling forth irritant phenomena on the part of the nervous system; the appearances of depression, of hyperirritation, and of relaxation usually soon follow.

Thermal stimulation too intense for the irritability will tend to lower the faculty of perception in the particular nervous tracks, or even suspend it altogether in corresponding periods of operation ; it may lead finally to sensory and motor paralysis, and, when extended over a large territory, may even cause death by too violent action upon the nervous system, or, analogous to the shock in major surgical operations, lead to the so-called nerve apoplexy. Here might be reckoned the most cases of paralysis, and even death, after very hot or cold baths which are recorded in literature. Therapeutically, therefore, we can obtain by thermal interference nervous stimulation, hyperstimulation, and non-stimulation. We are in a position *to heighten innervation; to lower, abolish, or alter it; and this, at the point of application, in the central organ, and, by reflexion, in the most varied motor and vasomotor tracks.*

Thermal stimulant actions are therefore indicated *when innervation requires to be strengthened, suspended, or altered.*

If the irritability of individual nerves or of the whole nervous system requires to be lowered, our efforts will be directed to obtaining *hyperstimulant effects.* In the latter cases, however, we will oftener make use of the method for *averting stimulation.*

General Laws of the Actions of Thermal Stimuli.

If we desire to find a therapeutical application for these facts, which have been confirmed by my own and foreign experiments, it is necessary to ascertain first of all the con-

ditions which the result to be estimated beforehand imposes. We therefore turn to those laws by which thermal interferences show such great variations in their action, and to the investigation as to how these actions may alter definite nutritive processes or influence them in different ways. To begin with, the magnitude of the stimulation is of importance to the effect. Stimulants not too strong for the irritability heighten it, whilst stimulation too strong for the sensibility lowers it, and may even destroy it. Washing a part of the skin momentarily with water of medium temperatures, 8° to 12° and 24° to 36° C. (46·2° to 53·6° and 75·1° to 96·8° F.), heightens the perception of touch in the particular spot; the points of a compass, perceived only singly before at a certain distance, are now felt double; different temperatures, formerly not distinguishable from each other, are now correctly designated as either hot or cold; muscles lying beneath this particular spot on the skin, previously impervious to further stimulation by a current of a certain strength, will now respond to the same current.

Very high and very low temperatures, e.g. the contact with ice or boiling water, will lower the sensibility to stimulation, indeed may perhaps destroy it. It is true that the magnitude of the stimulation will at the same time also *depend upon the duration of the impression*. A passive application of the same stimulus will occasion stimulant effects, and if of longer duration, hyperstimulant effects. These facts discovered by Waller, Rosenthal, Eulenburg, myself and others, show therefore (to summarise) that the magnitude of the action of thermal stimulation upon sensory, motor and vasomotor nerves is dependent upon the intensity and duration of the impression. But still another (third) factor requires to be noticed, since the result is also materially dependent upon it. This factor is the mode of the stimulant attack, whether it be a gradual insinuation or a suddenly applied force. Valentin formulates the physiological basis for the operative difference between suddenly applied and insinuating thermal stimulants thus: 'Very weak electric currents do not operate visibly and, as the alterations induced thereby do not take place quickly enough, every other kind of stimulus will similarly remain unsuccessful when externally applied. For instance, it is possible to exercise

considerable but very slowly applied traction upon the sacral plexus of a frog without thereby inducing twitchings. In tumours the same occurs under diseased conditions. A piece of ice laid on the sacral plexus of a frog kept in a temperature of 10° to 20° C. (50° to 68° F.) will often bring on lively muscular contractions in the hind legs. If the sacral plexus be cooled down to 0°, and less, by covering it with a piece of gutta-percha tissue of the thickness of foreign note paper and laying cotton wool saturated with ether thereon, everything remains quiet even though sensibility is not destroyed by this procedure. The same double experiment succeeds according as warm water is poured upon the sciatic nerve, or cold water in which it is placed is brought up to the same temperature by cautiously adding warm to it. The sensations display similar though slightly deviating phenomena. Sudden impressions have tumultuous, the gradual less agitating consequences, which are on that account often less perceived or even not at all noticed. The same light which would not at all blind our eyes under ordinary circumstances, immediately does so when we come directly out of the dark into the light. The powerful operation of contrasts rests upon the rapid springing over from one materially different sensation to another.'

The validity of this law in man has also been proved. Transferred suddenly to a warm or cold place, we perceive alterations in temperature sooner and more acutely than if the chamber in which we are was slowly cooled down or heated. By dipping a finger in water of moderate temperature which is only gradually heightened, we will bear without hurt degrees of temperature which would be painfully experienced were the fingers suddenly immersed. Gradual cooling down or heating of the water in which a limb is immersed may be either not at all perceived within a range which may consist of several degrees, or be estimated quite inversely.

Finally, one other factor in thermal effects is of importance. This is *the condition of the sensibility for stimulation before the operation.* And it is in our power also to influence this sensibility by different temperatures, one of the most important means of accomplishing this being the combination of high and low temperatures. Previous warming as a rule heightens

the sensibility to stimulation for subsequent cooling down, from which will be seen the appropriateness of warming procedures prior to the application of cold. From what we have just seen we may deduce that when stimulant effects are indicated —when innervation is to be increased or suspended, altered or reversed—we will select the passive application of low and high temperatures in combination with, as I shall here anticipate, the aid of *a powerful mechanical impression.* Water at 8° to 12° C. (46·4° to 53·6° F.), in the form of ablutions, rain-water baths, jet douches, drenchings, and passive shampooings, with a duration of from a few seconds to several minutes, here find their application. When we require hyperstimulant effects we must have recourse to the long-continued actions of very low, more rarely of high temperatures. Half and whole baths at a temperature of from 10° to 18° C. (50° to 64·4° F.), often lasting from half an hour to an hour; the opposite effects of cold and heat; alternative friction, baths and vapour baths, with subsequent energetic cold impressions, will accomplish this requirement. In these cases however, we will oftener obtain results by antistimulation through temperatures nearly approaching that of the body, the so-called indifferent temperatures. This action of non-stimulation can be still further supported and heightened by the addition to the thermal agent of certain substances—*substances capable of reducing the thermo-electric contact current to a minimum.* I have found the addition of a slimy substance peculiarly well adapted for this purpose, e.g. a bran decoction.

Let us now examine in detail which organic functions are principally acted upon by stimulation, hyperstimulation, and antistimulation; and first of all, endeavour to find out what alterations take place at the point upon which the temperature changes have operated, and throw light upon the processes dependent thereupon.

Thermal and mechanical stimuli applied to the dermal organ act as cutaneous irritants. We are in a position, therefore, to cause as strong a degree of stimulation as we please from simple reddening to absolute death and charring of the structures met with. Temperature stimulants, as compared with other cutaneous irritants, only present one other great

advantage, namely that one is able to fix much more accurately the amount of irritation by the degree of temperature than with other epispastics, and that it is possible to obtain—according as a large part of the body or the whole of the dermal superficies is chosen and according to the number of sensory peripheral nerve endings met with—actions of varying magnitude with an absolutely weaker stimulation according to the law of the accumulation of effects.

Influence of Thermal Stimuli at the Point of Application Itself.

On a sufficient local irritation being applied by means of a low temperature, we observe a paling of the irritated part to follow. We select this instance first, on account of the simplicity of the phenomenon. The muscular structures of the skin, the numerous muscular fibres contained therein, and the circular muscular fibres of the cutaneous vessels have contracted energetically, blood is driven from the skin which becomes anæmic, pale, and shrunken (cutis anserina).

The action of the cutaneous stimulation is not exhausted by this contraction of the dermal muscles and vessels at the stimulated spot. Organic or smooth muscular fibres possess the peculiarity that they only enter into play very gradually on adequate motive stimulation being applied, and return to their normal condition just as slowly. Only on very energetic stimulation do they contract more rapidly, and then only to relax the more and to lose their tonicity for a longer or shorter period—in fact, to be over-stimulated. At the point upon the skin which, touched by the cold irritant, first became pale on its application and then shrank—the cutaneous glands and hair follicles being protruded like little tubercles in consequence of the contraction of the dermal muscles—we now observe the skin to become smooth, and to undergo a change of colour. It becomes red through the increased flow of blood which takes place to the surface by the dilatation and relaxation of the vessels. The lymph spaces also of the insterstices of the tissues become filled with their respective fluids, the part thereby becoming not only red, but also somewhat more

succulent. The force of the circulation is increased during this period, as experiments on transparent, living animal subjects have shown. Allow the low temperature still further action and the redness becomes more and more intense; the part becomes dark red and bluish successively, and ultimately, if the cold influence be driven any further, even dark reddish blue. During this period the movement of the blood current is slowed until at last all the phenomena of a venous hyperæmia, ay even to complete stagnation or stasis, are present. All these facts may be proved at any time on the aforementioned subjects.

Anæmia therefore follows stimulation by cold at the place of application; it is however soon followed by a lively congestion of the stimulated part, which is next relieved by hyperæmia, and ultimately goes on to venous hyperæmia and stasis.

It is readily seen what important alterations of local nutritive conditions can be arrived at by even this simple alteration of colour in the part meeting with the low temperature. At first we have a diminished amount of blood in the skin and subcutaneous cellular tissue, expulsion of lymph and interstitial fluids from the lymph spaces and tissue interstices by contraction of the vascular muscles and muscular elements of the dermal organ; then diminished interchange between the blood and tissues, lowering of the temperature of the part by diminution in the heat supply as well as diminution in the amount of heat given off, and of organic function shortly after; we have the blood content increased, the circulation at first quickened, and the resistance to it diminished; promotion of local diffusion processes; acceleration of local tissue metabolism; increased heat supply and increased discharge of heat. During later periods of the cold action we again obtain a slowing of the circulation through the delayed and obstructed return of the blood; the blood remains longer in contact with the tissues, and becomes more venous thereby. The delayed return effectuates a slower penetration of cold to the internal organs, as the moving blood is the most efficacious equaliser of the temperature between the body and media in contact with it.

We have then here already made the acquaintance of manifold alterations of local nutritive conditions which it is in our power to regulate by means of local thermal stimulants longer or shorter in duration. Local high temperatures will operate in a similar manner. Higher degrees of heat also, will call forth a rapidly passing vascular contraction which is soon followed by relaxation of the vessels. After a somewhat longer stage of hyperæmia there also appears under an excessive heat influence (albeit somewhat later than in the previous case) a loss of the tonus of the vessels, and delay in the blood motion thereby, passive hyperæmia, and processes similar to those just now described as taking place under the influence of cold.

The behaviour of the local conditions of the circulation is quite a different one under a single passive cold stimulation which is gradually toned down in order to be succeeded by warmth, not to exceed the temperature of the blood. In this case there is also a nervous stimulation induced during the first moment, and the blood is dispersed; but, in accordance with the old maxim, '*Ubi irritatio, ibi affluxus*,' there will soon be, at the place of the first cold impression, a dilatation of the vessels, quickening of the blood current, and greater succulence. During the later periods however it never goes on to passive hyperæmia and blood stasis in this instance, but moisture and blood heat effectuate simply an active congestion which, supported by the moist vapour, will bring about an acceleration of cell life and of processes of nutrition and of diffusion. *Upon these processes rests the 'modus operandi' of all so-called excitant cold applications.*

Besides acting upon the superficial vessels at the point of contact, thermal stimulation acts also upon the more deeply situated larger arteries. They however, are not so immediately nor directly reached by thermal and mechanical stimulants. The stimulation only reaches them as a reflected one, transmitted perhaps by peripheral ganglia; the stimulation to innervation and contraction is therefore a much weaker one, and will not so easily bring about a relaxation of these large vessels according to the laws for the action of cutaneous stimulation, but will keep them in a state of contraction for a considerable time.

This only applies to low temperatures. High temperatures have an opposite effect upon the large vessels beneath the place of application, inasmuch as they cause them to dilate; as soon as the contraction in the deeper large vessel begins to relax and the vessel commences to dilate, it is possible by repeating the cold stimulation to cause the vessel to contract renewedly. Only excessive and peculiarly acting stimulation by low temperatures is capable of producing, in the depths of the part operated upon, vascular dilatation, loss of tonicity, and relaxation.

The Influence of Cold and Heat upon Parts of the Body situated peripherally to the Place of Application.

The contraction of the larger arterial vessels of a part must exercise an influence upon the circulatory conditions peripheral to the contracted part as well as upon those situated centrally to it. This influence will be so much the more important a one the greater the calibre of the narrowed vessel and the more powerful the constriction is. The artery in its contracted condition will only allow a smaller amount of blood, corresponding to its narrowed diameter, to pass through in the same period of time. The chief result obtained therefore, will be a diminished blood supply to the part situated peripheral to the narrowed portion. It is easy to comprehend to what a considerable extent the contraction of a larger arterial trunk is capable of reducing the blood supply to its own region of distribution, when we remember that the lumen of an artery can be reduced to a half and third of its size, or even to complete occlusion, under a sufficient stimulation by cold. Reduction of a vessel's lumen to a quarter of its diameter brings its capacity down to a sixteenth of the original one; in fact, upon this action rests the styptic property of cold in hæmorrhage. Vessels situated peripherally to the contracted portion will now accommodate themselves to the lessened amount of blood and reduced current; they will therefore also contract and exhibit more tonicity.

The influence of low temperatures upon the vascular distribution peripheral to the point of application as just described, has not only been theoretically elucidated by me, but I have

also shown the first direct proofs hereof by means of the sphygmograph and plethysmograph as early as 1864. I therefore cannot resist demonstrating graphically what we have just discussed, by means of a sphygmographic and plethysmographic curve (see fig. 35).

There is a remarkable alteration to be seen in the curve in its second section, which was taken after the application of an ice poultice to the arm, the first section being the tracing of a normal, moderately tense pulse, displaying a very marked dicrotism. The steep ascent is reduced to less than a third of its former straightness, the waves of elasticity are indicated in the line of descent, whilst the recoil waves, so plain at A, are hardly to be recognised even as traces at B. These alterations certainly indicate that the lessening of the diameter by contraction of the vessel corresponds to the diminished capacity and elevated tension of the arterial tube.

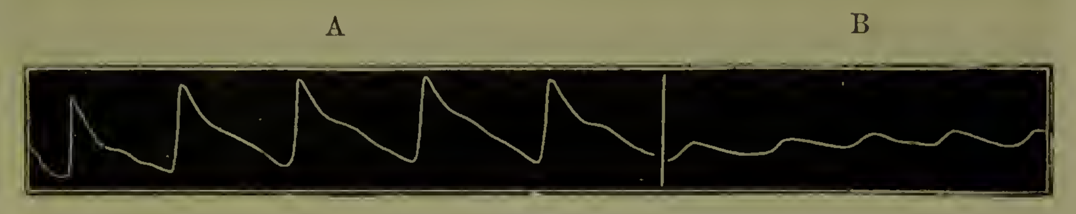


FIG. 35.—Curve of radial pulse. A, before; B, after the application of ice poultices to the arm.

The wave of blood driven into the particular vessel with each systole of the ventricle is accordingly a smaller one, and is also incapable of much distending the already tightened tube. The absence of dicrotism must be attributed to the almost complete occlusion of the conducting arterial trunk upon which the weaker recoil wave is broken, whilst the more powerful systole still drives a quantity of blood through the narrowed portion and forces the vascular tube to distend to a moderate extent. The slanting line of ascent points to a considerable elevation of the arterial tension. Thus we see it is possible to demonstrate graphically that the contraction of a larger vascular trunk—called forth by the exhibition of cold stimulation—operates upon the region of vascular distribution peripherally to the constricted portion of the vessel very similarly to an incomplete deligation; the blood supply to the periphery is diminished thereby.

This diminished blood supply to the periphery may also be recognised by a lowering of temperature in the corresponding portion of the body. The temperature of a part is namely absolutely dependent upon the mass of blood conducted to it, and rises and falls in exact proportion to this. The contraction of an arterial blood-vessel causes a reduction of temperature within its whole circulatory region. I have often observed, e.g., after cold applications to the arm, a sinking of temperature amounting to a whole degree or more, in the palm of the hand. It is possible to keep the temperature permanently down by renewing the application. As we shall learn more intimately

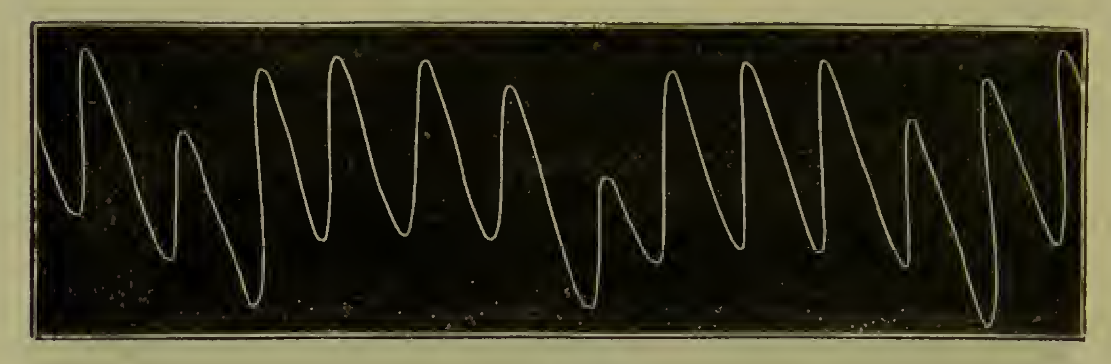


Fig. 36.—Curve representing the changes in volume of an arm immersed in water at 38° C. (100·4° F.)

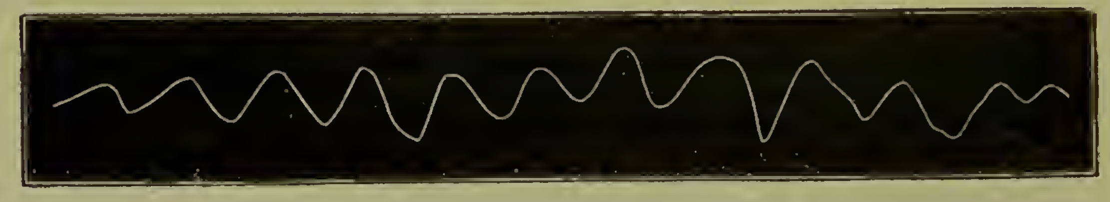


Fig. 37.—Curve representing the changes in volume of an arm immersed in water at 8° C. (46·4° F.)

when treating of the hydriatic methods, the degree of temperature reduction and permanency of the effect, as well as the height of the consecutive reaction, will depend upon the frequency with which the applications are renewed and the degree of temperature of the cold vehicle which constitutes the application.

By means of the volumometer, an instrument after the model of Fick's boot-sphygmograph, I was also able to demonstrate thermal contraction and relaxation of vessels, prior to Mosso, who constructed his plethysmograph on the same principle.

The curve taken from the arm immersed in warm water shows, when compared with that of the arm placed in cold

water, very considerable differences. The volumetric fluctuations, dependent upon the blood wave thrown into the arm with each cardiac systole, are much greater in the first case than in the second. The stimulation by heat showed vascular dilatation, and therefore, with each systole, signs of larger blood waves being sent into the arm—the cardiac power being the same, of course—whilst the increase in volume, corresponding to the systole in the case of the arm in cold water, is a much smaller one. We may conclude herefrom with certainty, that the nutritive conditions in a portion of the body whose arterial supply has been placed in a condition of contraction will be considerably altered.

Since the amount of the blood supply and the height of the temperature are the measures for the energy with which the organic functions of the body are carried out, we have it in our power to lower the organic activity of any peripheral part, and we are still further able to bring about the resolution or to cause the removal of disturbances through any organic defects in the blood supply, the formation of heat or the local metabolic changes, whereby they have been pathologically increased. In like manner it is in our power to increase the blood supply to a part by using higher temperatures, to accelerate the blood current in it, elevate its temperature, and to favour local processes of nutrition and of tissue metabolism.

Influence of Various Temperatures upon Parts Situated Centrally to the Point of Application.

Exactly opposite phenomena may be recognised *above* the thermally contracted portion of a vessel in the course of the current—phenomena which are quite different from those we found towards the periphery and have just described.

Upon more centrally situated portions of the region of distribution of one of the larger vessels which has become narrowed, this constriction will act as an obstruction to the current of greater or less magnitude according to the calibre and degree of contraction. Above the contracted portion stasis must take place, i.e. the column of fluid will be more tense and exercise a greater lateral pressure upon the walls of the tube, since the

quantity of blood and the force with which it was circulated have not been diminished. The fluid under higher pressure endeavours to escape by collateral roads; hence collateral hyperæmia and dilatation of the vascular conveyances adjacent to the obstruction take place. The phenomena by which this collateral hyperæmia is recognised consist in a somewhat higher degree of reddening of the particular parts and a corresponding condition of the pulse; the arteries dilate and feel hard. The immediate consequence of this hyperæmia of retrostasis must be an elevation of temperature of the corresponding portion of the body. As far as I know, I was the first to observe this and to point out already in 1865 that, during the application of cold to the arm for instance, the temperature in the palm of the hand is lowered, whilst that of the axilla is simultaneously raised. The elevation of the axillary temperature seems to me to be the effect of the circulatory obstruction caused by the contraction of the brachial artery and of its distributory appendages; in short, the effect of collateral hyperæmia. Here also it is the work of method to indicate in what regions we require to cause collateral hyperæmia by thermal influences, where we require to avoid such an one, and in what cases it would be therapeutically applicable. In any case it is possible from what has just been said to gather in a general way what powerful impressions we can produce, by thermal contracting and relaxing stimulation, upon certain vessels and vascular provinces, on the total capacity of the circulatory system, on blood pressure, and on blood distribution; still further, how powerfully we can influence the most diverse processes of nutrition, and the various conditions thereof, for it is *upon the distribution of the blood and upon pressure and tension in the vascular system, that the most important organic functions of the body depend.*

In collateral hyperæmia and the retrostasis of the blood to different organs we have not only curative factors hitherto too little estimated but at the same time a source of manifold danger, common to all thermal procedures. The collateral determination calls forth a reaction on the part of the vessels involved against the dilatation of their walls, in consequence of which they contract energetically and drive the stased blood

back upon the primarily contracted vascular region. This process is described as reactionary determination—reversion of the current—the therapeutic value of which Schüller, in particular, has put forth in a comprehensive manner. By this reversion of current we are able to deplete intermittently organs previously passively hyperæmic, to restore them to their normal tonus, and to stimulate the tissue metabolism of individual organs, inasmuch as acceleration and rapid change of the blood stream keep up the continual supply of new material for the organic processes. This reversion of current becomes of still greater importance, however—as I have shown in rheumatic and neuralgic affections—when by it the convection and washing away of the products of decomposition and retrograde metamorphosis accumulated in the diseased organs, and which must often be looked upon as the causes of disease, are promoted and facilitated. There may be also a danger in the primary thermal congestion by retrostasis, against which it is well to guard. Vascular provinces too, a congestion of which might prove detrimental—for example, the cerebral vessels, especially when pathologically altered by atheromatous processes, or when the vessels are too brittle or tender—must be guarded against retrostasial congestion ; the particular vessels must be placed in a condition of higher tension prior to the cold impression, in order to be able to offer a greater resistance to the wave which stasis sends against them. It is therefore a rule allowing of only the very rarest exceptions, that every operation of cold water upon the periphery of the body should be preceded by an extensive fortification against retrostasial congestion of all organs to which an increased blood supply might be injurious. This indication will be fulfilled by means of cold applications of from 1 to 5 minutes' duration, which are made over the imperilled organ. Cold ablutions of the face and head, repeatedly cooling the eyes, cooling the axilla, and wet bandages to the head repeated several times in quick succession, are the manipulations required for this purpose.

Reflex Actions of Thermal Influences.

Thermal stimulation does not alone influence the blood vessels of the part acted upon, and the regions of supply and

discharge dependent thereon, but, according to the law of the stimulation of cutaneous nerves by reflex, it also acts by means of the sensory peripheral nerve endings upon other vasomotor tracks—ay, even upon the circulation in the most remote organs, as we have already pointed out above. The vasomotor operations of the cutaneous stimuli are therefore of the utmost importance to the physiology and pathology of water actions, and here again Naumann's laws, so exactly laid down, are of great service.

Laws for the Actions of Cutaneous Stimuli.

Naumann's fundamental experiment, by means of which he ascertained the mode of action of cutaneous stimuli, was as follows: He prepared a frog, which he had killed with the utmost possible care of the medulla oblongata, for the microscope by means of separating the vertebral column from the head without severing the connection of both parts, in order to avoid hæmorrhage as much as possible, and in such a manner as to allow the circulation in the mesentery to be well seen. He deligated the vessels of one thigh in order to avoid any impression upon the vascular system during the stimulant experiment, and then cut through all parts of the thigh below the ligature with the exception of the sciatic nerve, so that the trunk remained connected to the thigh only by means of this nerve. The end distribution of the sciatic nerve of that foot being now stimulated either electrically, chemically or thermally, and the circulation in the mesentery being simultaneously observed through the microscope, an unmistakable alteration in the rapidity of the blood current was observed in its vessels. These phenomena are not only to be seen in the mesentery; they may be followed in other vascular regions as well.

The conclusions arrived at by Naumann as the results of his experiments are, for our subject, of most importance in the following particulars :—

1. The action of epispastics is essentially brought about, by means of reflex action through the central organs.

2. These agents exert a considerable influence upon the activity of the heart and vessels.

3. In proportion to the irritability of the individual, powerful cutaneous stimuli will lessen the activity of the heart and vessels and weaken the contractions of the heart, the vessels becoming dilated and the circulation slowed. They act hyposthenically.

4. Relatively weak stimulation increases the activity of the heart and vessels, will strengthen the cardiac contractions, narrow the vessels, and accelerate the circulation. It acts hypersthenically.

5. The changes brought about in the body by a cutaneous stimulation of long duration, last a considerable time after the conclusion of the same; as a general rule, they will last longer the more enduring the stimulation applied was, and in a healthy person will often still be perceived after the lapse of from a half to three quarters of an hour from the period of conclusion of the stimulation.

6. The relaxation of the pulse which follows a more powerful cutaneous stimulation often attains its maximum during the stimulation, but often only after the conclusion of the same.

7. The excitant action of a relatively weak cutaneous stimulation likewise continues for a considerable time after it has been removed, but it is finally also followed by a relaxation, only that this appears much later and in a less degree than after more powerful cutaneous stimulation.

8. As a consequence of a stronger cutaneous stimulation, there constantly appears, mostly after a longer or shorter period of warming, a cooling down of the body, which often has not terminated half an hour after the cessation of the stimulus.

9. This period of alteration in temperature is of varying duration; cooling ofttimes takes place during the stimulation, but as a rule only after its conclusion.

Actions of Temperature upon the Heart.

Amongst the *reflected actions of thermal cutaneous stimulation* the influence it exerts upon the central organ of the circulation, namely the heart, deserves most attention. The influence exerted by low and high temperatures upon the heart's

action is of a twofold nature. At one time it is the reflected impulse of innervation directly following the impression which here makes itself most felt, at another time it is the equalisation of the temperature, brought about by the contact with different temperatures, the withdrawal or supply of heat, the lowering or elevation of the temperatures of the body and of the blood which influence the heart's action. The proof that the former really depended upon a stimulation transmitted through sensory tracks to the origin of the vagus was brought by Röhrig, inasmuch as he showed that the division of the vagi suspended this primary action of stimulation by temperature upon the heart's action.

I believe that I was the first to have graphically demonstrated the primary thermal stimulant effect upon the action of the human heart, and it was then that I found that every impression of low temperatures upon the superficies of the body was immediately followed by an acceleration of the cardiac action. It was only possible to ascertain this primary action by means of a graphic pulse-tracing, continued through the whole experiment. The primary pulse acceleration had hitherto been overlooked, since it is only a very passive one, and the inaccuracies occasioned by counting the pulse are here particularly felt. The application of cold for a longer period lessens the number of cardiac contractions—as also happens some time after the receipt of a rapid impression—the frequency of the pulse being diminished. High temperatures brought into contact with the surface of the body immediately produced an unmistakable slowing of the heart's action, followed rapidly however by an acceleration of the same. The increase in the frequency of the pulse rate following cutaneous stimulation by a low temperature is not the same in all individuals; according to the susceptibility to irritation will the effect in one case be a more powerful and permanent one, in another less intense and more passive.

Generally speaking, the increase in the frequency of the pulse will be more considerable the slower the heart's action has been prior to the action of the cold. I was not able to ascertain the primary accelerating action of thermal cutaneous stimulation in the pulse of fever or disturbances of innervation

accompanied by a quickened cardiac action, e.g. Basedow's disease. Under conditions such as this I observed that a slowing of the pulse immediately followed the cold impression. The lowering and elevation of temperature seem to act from the blood mass upon the heart's action by directly influencing the automatic cardiac nervous centres, the ganglion plexuses scattered through the heart. The observation, so often made, that cold and heat give rise to slower or more rapid contractions in an animal's heart cut out and disconnected entirely from the central nervous system can be construed in no other way. It has also been ascertained, experimentally, that when fluids of a low temperature are allowed to pass through the cavities of the heart the contractions of that organ will be slowed and weakened, and can finally be even altogether suspended. This experiment also speaks in favour of the assumption that by the temperature of the fluid blood, influence can be obtained over the nerves distributed to the endocardium, for if the fluid which we cause to circulate be made somewhat warmer there will be at first acceleration of the cardiac contractions. The excited heart, cooled down during the animal experiment, lessens its contractions exactly as when in the living body the temperature of the blood is really lowered; and similarly the beats of the excited organ are accelerated on the application of heat as they are in the body under the influence of fever or an increased heat supply. But not alone upon the frequency of the heart's beats can we operate definitely by means of thermal interference ; the power of the heart also becomes altered under these conditions. Sometimes the power of the heart is dependent upon the tension in the vascular system, and I have explained above how we are able to influence this by thermal means. On the other hand, it appears possible to stimulate the heart to more powerful contractions by means of an innervating impulse reflectorially excited, and not too powerful for the stimulant susceptibility ; sphygmographic curves, which there is opportunity of taking before and after cold applications, settle this beyond all doubt. Clinical experience of which we shall have to speak later on, also proves it and furnishes the explanation for the great value of hydrotherapeutics in many severe compensatory disturbances in patients with heart disease.

Actions of Temperature on the Respiration.

We need not be surprised to hear that *respiration* in regard to *rhythm and depth can be altered by thermal influences* when we remember that the nervous central organs for it and for the movements of the heart are in point of space situated very closely to each other. Cold and heat then, act also upon the respirations; the former by causing the delivery of a spasmodic, deep inspiration—at least, the first shock of cold usually—at the climax of which there is a pause in the respiratory act which then passes on into a longer stage of accelerated breathing. Heat also seems to heighten the frequency of the respirations somewhat. As a general rule, the well-nigh stationary proportion between pulse and respirations will undergo an alteration through the influence of cold. It is all the more doubtful whether this alteration, viz. that after a cold impression there is a greater number of respirations to each pulse wave, or that on each respiration fewer beats of the pulse come to fall, is in so far of importance to the exchange of gases (as has been assumed) as that each individual quantity of blood remains a longer time in contact with the atmospheric air, since numerous thorough investigators have opposed this view. On the other hand, a certainly not unimportant part falls to the lot of an involuntary alteration in the respiration following temperature influences for the reason that, as we shall see, the movement of the blood—and especially that of the lesser or pulmonary circulation—is thereby hurried, and that the processes of heat regulation might also further be influenced thereby.

Deep inspirations will promote the return flow of the blood—that is, the circulation in the venous vascular regions—but make the arterial current more difficult and lower the pressure in the aortic system. Deep expirations, on the other hand, facilitate the centrifugal or arterial blood current, and render the return of the blood to the heart more difficult. Hence thermal cutaneous stimuli have a considerable influence upon the respiratory act.

Thermal Influences upon Blood Pressure and Distribution.

It is of great importance to the theory of hydrotherapeutics that it should be to a certain extent looked upon as a

hydraulic therapeusis. High and low blood pressure are undoubtedly of the utmost importance to the more intimate processes of tissue metabolism. The velocity of the blood current depends upon the positive blood pressure in the arteries, as does also the constancy of the current in the smallest arteries, in the capillaries, and in the venous system. Processes of secretion and excretion and the manifold phenomena of diffusion are surely dependent upon the blood pressure and rapidity of the circulation. The anatomical relations are the given constant condition. The direction of the insertion of vascular branches into the trunks of the vessels and the arrangement of the capillaries seem to determine the pressure and rapidity of the stream in each individual organ, and thereby to render its various functions possible. Leaving abnormal conditions, injuries, and similar matters out of question, it is only possible, according to physiological laws, in a closed hydraulic system—as is represented by our circulatory system—for a perceptible and rapid alteration to occur by either *a sudden lowering or elevation of the motive power of the heart*, or in that *the capacity of the vascular system is subjected to sudden great variations*. We have already shown that we are in a position to act upon the driving power of the heart. It is questionable whether the total capacity of the vessels will rapidly undergo a perceptible alteration by thermal dilatation or narrowing of a large vascular province, since a great number of compensatory appliances exist which, it would seem, keep the capacity of the vascular system upon the whole nearly balanced, and thereby variations of pressure are avoided. Physiology teaches us numerous facts which show that during the narrowing of one vascular province a dilatation of the other takes place. Dilatation of the abdominal during narrowing of the cutaneous vessels, and *vice versâ*—the blood pressure remaining unaltered thereby—has been often enough observed. If we require still further to show that dilatation or narrowing of a large vascular province has an influence upon the blood mass and blood pressure in the non-dilated vessels, we must again look for the answer to this question to physiological experiment. Goltz showed that by means of repeated tappings upon the undamaged abdominal parietes of a frog it was

possible to make the heart beat slowly, and even to bring it to a standstill— into a condition of relaxation in fact. The return of cardiac activity some time after the cessation of the taps showed a similarity to the condition left after heavy losses of blood. The venæ cavæ remain nearly empty, in the webs of the feet the movement of the blood is hesitant, and divided arteries hardly bleed at all. What can have become of the blood, since there was no division of nor injury to a vessel and no hæmorrhage? At the post-mortem examination after the tapping experiment, Goltz found the vessels of the mesenteries, especially the veins, enormously distended and overfilled with blood, not a vessel however showing a solution of continuity. The vasomotor nerves therefore which meet with the stimulation either directly or by reflection are paralysed by the mechanical concussion, the vessels supplied by them relax and dilate (perhaps it may be the inhibitory nerves which call forth this effect; this is, however, immaterial to the result), the immoderate mechanical excitement causes a loss of tone such as other stimulants—e.g. corresponding cold impressions—are also capable of producing. What influence must such a loss of tonicity in a larger vascular region have upon the whole of the circulatory conditions? 'As soon as the whole capacity of the vascular system has become greatly enlarged by the relaxation of the muscular walls of a considerable vascular region, it is not possible for the whole of that system to be still exuberantly filled with blood. The heart throws a quantity of blood into the arteries with each systole, which these greedily absorb without being made tense by it, as they can now hold more blood than they did before. In like manner the relaxed veins retain any blood which may be still flowing into them, so as to fill the space within them now at their disposal. Thus the relaxed vessels enrich themselves at the expense of those at normal tension, which they deprive of their contents, and so of the cause of their tension. But by this relaxing or expiring tension of the vessels the activity of the heart is gradually made to suffer more and more. At first the great veins are still tense, then the overplus is discharged with every diastole into the heart, whose contractions drive it into the dilated vessels; for the greater part, it is retained by the latter, very

little flows back to the large veins and to the heart, their tension sinks rapidly, and the quantities of blood they give to the heart with each diastole become smaller and smaller. The suspension of tension in a large vascular province causes injury to and even total loss of the tension in the vessels remaining normal. If the activity of the heart be paralysed by a suspension of tension, a modification thereof must at least weaken the operations of that organ, e.g. a lowering of universal vascular tension, whereas an increase of tension will, *cæteris paribus*, elevate the activity of the heart.' The division of the splanchnic nerve gives rise to phenomena similar to those observed after the tapping experiments of Goltz. The abdominal vessels dilate, the blood is, as it were, aspirated by them, the vessels with normal tension at first seek to accommodate themselves to their diminished contents; their filling in the manner described is however quite inadequate, and they also lose their normal tension. All visible vessels of other parts of the body contract to their maximum extent, their contents being reduced to a minimum. Intense anæmia appears in all these parts, and manifold disturbances of function which crop up can be accounted for by this unequal distribution of blood.

The dilatation of so large a reservoir of blood as that governed by the splanchnic will produce very widespread collateral anæmia when that nerve is paralysed, just as we saw that *the contraction of a larger vascular district will cause collateral hyperæmia.*

On the other hand, we must seek for some apparatus in the abdominal vessels supplied by the splanchnic nerve which is adapted for regulating the blood pressure within very wide ranges, and which is capable of compensating, by enlarging the capacity of the vessels, an increase of tension in any one district.

Hence it is quite easily understood how, if we except such extreme alterations as are brought about by Goltz's tapping experiment or the division of the splanchnic according to Asp and Von Basch, a moderate amount of narrowing or dilatation of a certain vascular region can exist without exerting any influence upon the blood pressure as a whole, inasmuch as other vascular provinces undergo compensatorial changes simultaneously.

This will explain the possibility of sometimes enveloping the whole animal body in snow without interfering with the blood pressure, as Horvat asserts he has observed to be the case.

In spite of the theoretical objection that generally the total blood pressure might not be altered to any great extent, nor permanently, by means of the thermal stimulant factors therapeutically applicable, direct experiment shows this always to be the case to a certain degree; the particular proof for this has been brought by Schüller in the living animal, and by myself in man. Schüller observed the vessels of the pia mater in rabbits after trephining the lateral walls of the cranium at both sides of the sagittal suture. The dura mater in most cases remained intact, and its transparency allows the observation of the vessels in the soft meninges of the brain. In this way Schüller found that even pressure upon the belly of the animal under experiment was quite sufficient to cause a dilatation of the veins of the pia mater, sometimes even of the arteries as well. This phenomenon is explicable by the mechanical obstruction to the venous reflux. Pieces of ice laid upon the dura mater cause a very energetic contraction to take place in the arteries as well as in the veins, which still lasts 30 seconds after removing the ice. A cold wet compress laid upon the belly or back of the animal causes, almost without exception, immediate and lasting dilatation of the vessels of the pia mater; a warm wet compress upon the back or belly of the animal has the opposite effect—namely, more or less energetically lasting contraction of the pial vessels. Whole baths have even more intense influence upon the vessels of the pia mater than the compresses.

During the use of cold whole baths it will be observed that the dilatation of the vessels is the greater the more of the animal's body is immersed, the cerebral movements at the same time becoming slower but more extensive. It is only after a longer period spent in the cold water that, in consequence of the powerful cooling down of the blood, contraction of the vessels and collapse of the brain take place, often after preceding fluctuations in the calibre of the former. The aural vessels

also usually dilate, unless the ears were likewise submerged; the secondary contraction appeared in these—after a longer sojourn in the water—much earlier than in the vessels of the pia mater. After the conclusion of the experiment the vessels of the pia mater again contract and remain in a state of contraction very often for half an hour. The warm whole bath is invariably followed, often after only a very transitory dilatation, by a powerful contraction of the vessels of the pia mater and collapse of the brain. The cerebral movements dependent upon the pulse, are at first accelerated but become slower and more superficial after some time, and finally, during increasing dilatation and after the bath, become again more rapid. A short dilatation follows a warm whole bath much more energetically if cold water has been applied directly after it. Lastly, the vessels of the pia mater are also somewhat contracted after the warm whole bath, before they return to their normal condition; very hot whole baths effect at first somewhat more permanent dilatation, and only cause contraction later on, as the water becomes cooled. Schüller further tested wet packing, which he often continued for 2 to 3 hours; the body temperature of the animal sinks by 1° to 2° Celsius during its application, and only after about 2½ hours begins to rise again. The respiration becomes gradually more slow and deep, the frequency of the pulse diminishing and the creatures reacting more slowly and less lively to stimulation—they seem in fact, to sleep. It is only with the commencement of the rise of temperature, that is therefore after from 2½ to 3 hours, that they become more lively. During the wet packing the cerebral vessels behave in the following manner: After a quick transitory dilatation they gradually contract, the brain sinks together more and more, whilst simultaneously the dura mater begins to rise in consequence of the cerebro-spinal fluid which has collected in great quantity. The cerebral movements get slower and obtain greater regularity, the phenomena continuing for hours. At first external irritation, pinching and raising the animal, call forth instantaneously more rapid cerebral movements and stronger indefinite filling of the vessels; later on, these manifestations become decidedly more difficult to call forth.

It is only in dry packing that the animals do not display these phenomena. The wet pack being removed, a powerful dilatation of the vessels of the pia mater at once takes place—rapidly however returning to normal—whilst respiration and the cerebral movements again become more frequent.

As we shall see, the phenomena observable in man during wet and dry packing coincide with that which has been verified to take place during the animal experiment in the most exact manner possible. For this reason I have given a minute description of this experiment.

Friction over the abdomen or back with a cold or warm wet towel is always accompanied by a more or less powerful contraction or an alternating change of calibre of the vessels of the pia mater. After the conclusion of the friction there is usually great but rapidly transitional dilatation. Rubbing with a dry cloth has the same effect upon the vessels of the pia, only in a less degree; the application of cold douches to the abdomen or back usually calls forth a rising and falling of the brain, which is at first irregular, then regular, slow and expansive, being the consequence of greater expirations and inspirations. The vessels display during these movements alterations in filling, and alternating dilatation and contractions. Following cold douches there was always noticeable a somewhat more considerable dilatation with increase in the convexity of the brain. Injections of cold water into the rectum never failed to cause a moderate dilatation of the pial vessels.

So far as hydraulic laws alone have any influence on the circulation of the blood, the facts discovered by Schüller under thermal actions will *a priori* be quite comprehensible if we remember that cold, as a general rule, causes vascular contraction at the moment of impression, whilst heat produces vascular dilatation at that moment. I was enabled, by means of experiments on the living human body, to bring most striking proofs for the facts discovered by Schüller, which were mainly that the contraction or dilatation of a vessel in a certain part of the body was accompanied and followed by a contrary behaviour on the part of the vessels in other parts of the body.

By means of the plethysmograph I have succeeded in

proving that the contraction produced by thermal influence in a large vascular district causes compensatorial dilatation of the vessels in other parts of the body. If a person is placed in an empty sitz bath with one arm confined within the plethysmograph, that instrument will describe a curve which runs almost at an equal level; if cold water be now rapidly poured into the bath, the curve will suddenly rise to a considerable height at the moment of pouring in the colder fluid, a sign that the volume of the arm has received a corresponding addition, and has displaced sufficient water out of the apparatus to cause the steep ascent of the curve. The volume of the arm and the curve tracing corresponding to it keep for a long period at nearly equal level.

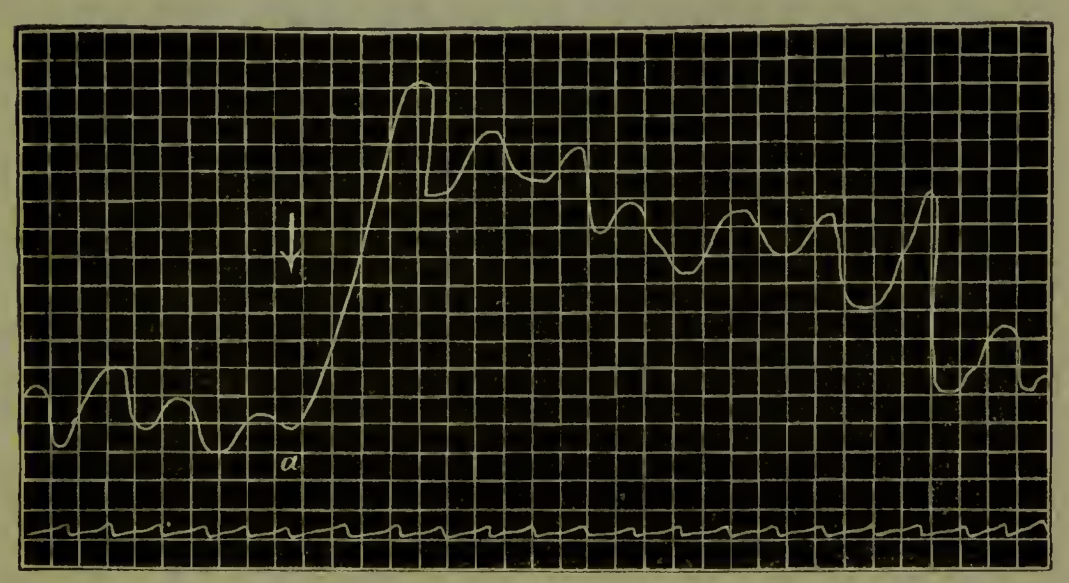


Fig. 38.—Representing the volume of the right arm before and during the continuance of a sitz bath at 8° C. (46·4° F.)

A glance at the accompanying curve, the first part of which was taken prior to the pouring in of the water into a sitz bath, the second after it had been filled, allows this to be seen in the clearest manner possible. For this sudden increase in volume of the arm, at the moment in which the cold stimulant meets the part of the body within the sitz bath, there is probably no other explanation than this, that the cold water has induced an excitation of the vasomotor nerves in reflex relation to the sensory nerve endings which are involved. This excitation causes a contraction of the vessels in a district of great size, the blood is forced out of them, and the supply

to this district is also obstructed. The necessary consequence hereof is, that a greater amount of blood is directed to other vascular provinces; the parts to which the increased supply of blood is sent must therefore increase in volume.

We were able to certify that an increase in volume took place during the cold sitz bath; the feeling of oppression coming on at this moment, the alteration in the heart's action, the somewhat heightened colour and turgescence of the face, and the feeling of heat in the head appearing with it all point to the direction of the current of the blood, under the conditions here given, being towards the upper half of the trunk, including the organs of the chest and cranial cavity. These grounds force us to the conclusion that it is principally the vessels of the pelvic organs which are forced to contract during the cold sitz bath, and that it is principally the abdominal organs to which the blood supply is restricted and from which the blood is displaced. It was only possible to prove experimentally such an action on the part of the sitz baths by means of the volumometer and thermometer, which simultaneously show an elevation of temperature in the axilla and the external auditory meatus; and I think it will not be out of place here to mention that I was the first who really ever brought this proof. The opposite experiment was just as successful and precise in my hands, and this lends even still greater weight to our conclusions. In this case also the volumetric curve of the arm was taken whilst the person sat in the empty bath; at a fixed moment warm water at 35° C. (95·0° F.) was poured into the bath, and the previously continuous volumetric curve exhibited at the instant of the pouring in a very brief increase in the arm's volume, after which the volume of the immersed part sank for a considerable period, ultimately to remain stationary at the point of reduction thus reached. This procedure is shown by fig. 39.

The first effect of the heat therefore was, corresponding to the experiments of Schüller, to cause a contraction of short duration of the vessels coming under the action of the thermal stimulant. This transitory vascular contraction must, however, have been followed by a vascular dilatation, called forth by the vaso-dilatory influence of the heat; the consequence of this

dilatation of a large vascular province must of necessity have been an increased supply of blood to it. The increased want on the one side could only be compensated for by a lessened supply of blood to other parts of the body, and this altered distribution of blood is made manifest by lessening of the immersed arm's volume. In our first experiment we have caused a displacement of blood from one part of the body to another by means of a thermal stimulus, and in our second experiment we have attained a practical draining off of blood from one region of the body to another; upon the whole, therefore, we have called forth an alteration in the distribution of the blood, although perhaps the tension and pressure

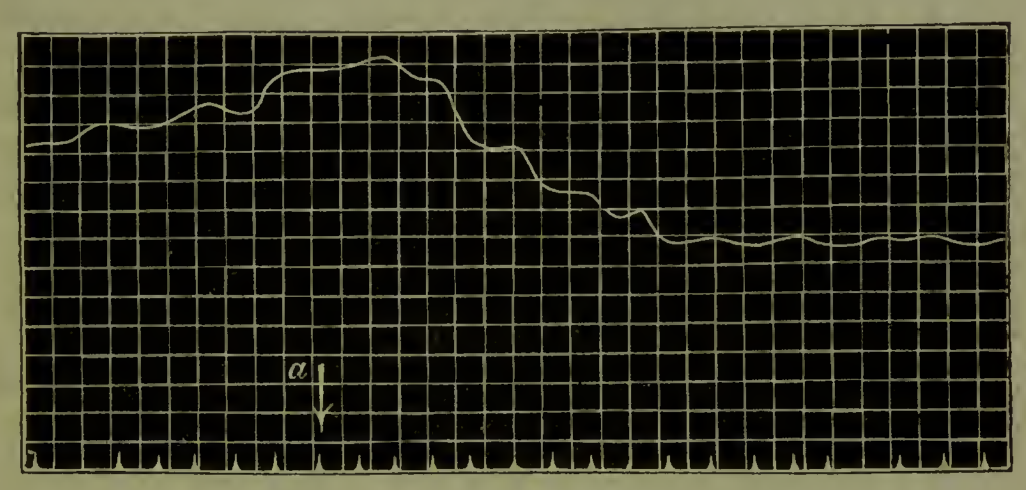


Fig. 39.—Showing the volume of the arm before and during a sitz bath of 35° C. (95° F.)

conditions in the whole system of blood vessels may not—taking all in all—have undergone any very material alterations.

If however we desire to cause a determination of blood to one or other parts of the body, *we must have lessened the blood supply to the other organs by just so much*, since the total amount of blood in the organism remains about the same within short periods of time. Ranke has taught us the value of this altered blood distribution for physiological processes, it being the principal factor in the alterations in function and activity of the organs. He brought the proof that an interchange exists between the activity of the individual organs of the animal body, in so far as with the heightened activity of one a corresponding diminution must take place in the activity of one or of all the other organs. The function itself will in like

manner be altered in ratio to the amount of blood in the organ; the functionating organ becomes full of blood, the quiescent one is anæmic.

In these laws of the interchange of activity and the phenomena occasioned thereby—particularly the altered blood distribution—therapeusis finds sufficient points of vantage for the suppression of abnormal nutritive processes. We here find a basis for well-nigh physico-hydraulic therapeutics; the whole of the so-called derivative and revulsionary methods rest upon the principles just described. For instance, if we find that a diseased process depends upon an increased blood supply to some organ or other, we must endeavour by dilatation of one of the vascular provinces at some distance from the diseased organ to diminish the amount of blood supplied to it, and to cause a direct diversion of the current from it. If a diseased process depends upon a diminished blood supply to an organ, it will be our endeavour to direct the tendency of the current to the anæmic part by calling forth vascular contraction in a large vascular region, *so as to direct blood to the diseased organ and to confine it there.*

The contraction or dilatation caused within a larger vascular district by hydriatic procedures will also make itself manifest in other vascular regions by opposite phenomena. It will not be difficult to apply to therapeutical purposes all the stimulant actions of different temperatures described up to this. We are able to gain absolute influence over innervation, we can control the circulatory conditions, locally and generally, and not alone are we able to regulate the amount of the blood supply to every part of the body, but also to influence the rapidity of the current; we can alter the heart's action at will, and also modify at will the conditions of pressure and tension in the system of blood vessels and in individual parts of the same; we can influence by these means the functions of the most varied organs, either by *plus* or *minus*, in *quale* or *quantum*; and we can control the secretions and excretions in so far as they depend upon innervation and circulation. Most particularly however, we gain a very powerful influence over the distribution of heat, and, as regards the latter, we are able to influence organic processes of the utmost importance,

as we shall more clearly demonstrate when treating of the processes of heat regulation further on.

(B) PHYSICAL ACTIONS OF DIFFERENT TEMPERATURES.

Deprivation of Heat.—Heat Supply.

One of the most wonderful phenomena of nature is the bearing of the body temperature towards external thermal conditions, the constancy of the bodily temperature under the most varied climatic conditions. We know that the living warm-blooded animal organism remains at almost precisely the same temperature, whether it be in the heat of the equator or in the cold of the polar regions. The mean bodily temperature of man and the warm-blooded animals amounts to about 37° C. (98·6° F.), at a difference in external temperature of very nearly 60° C. (140° F.) Since there can be no doubt that the physical laws are the only standard for the living animal body also, and that bodies of different temperatures coming in contact with each other endeavour to place themselves in a condition of thermal equipoise, we must, as a matter of fact, not be surprised at the first glance that the body remains at exactly the same degree of temperature, notwithstanding that in one case the medium coming in contact with it is perhaps about 70° C. (158° F.) below its own blood heat; or that in another, the temperature may be much higher than its own. Is this fact in harmony with the physical law just quoted concerning the equalisation of temperature between media in contact with each other? Or how is it to be explained that the cold medium does not cool down the animal body, nor the warm elevate its temperature above the normal mean? The rule that cold will lower and heat elevate the temperature holds good also for the living warm-blooded animal body. As a general rule, we have much too high a conception of the constancy of the temperature of the body under cold and warm influences; only within comparatively very narrow limits and under very favourable conditions is the body temperature ever in a position to withstand the thermal forces bearing upon it.

'No matter how manifold the measures may be which the nature of the more highly organised animals has endowed them with in order to enable them to maintain the heat of their own

interiors against the changes of external temperature as much as possible; and no matter how well they may understand, by their instinct, to support these measures—they yet only fulfil the requirements put to them within the very narrow limits of the most favourable conditions. Beyond these, as a matter of fact, the native heat of warm-blooded animals is wanting in that renowned stability which one has been in the habit of considering to be one of the most marvellous facts in nature. It was already known to older investigators, such as Edward and Legallois, that the temperature of mammals and birds did not under some circumstances withstand the influences of their surroundings. John Davy proved that the temperature of the warm-blooded animal gains about 0·5 to 1° C. in the transition from a cold to a warmer climate. Under the investigations of most recent date however, the dogma of the unwavering constancy of the warm-blooded animal's temperature has totally collapsed.'

We will now endeavour to show that the constancy of the body temperature, even of man, really only exists within the narrow bounds of favourable conditions, in order that we may demonstrate the foundation for this quotation from the very valuable work of Adamkiewicz. Senator was the first to show, so far as I am aware, that even the simple uncovering of the body at a room temperature of 14° to 16°, even to 27° C. (80·6° F.), suffices to reduce considerably the temperature when taken in a fold of integument. Even the slight deprivation of heat which may be caused by simply undressing in a room heated to 19° C. (66·2° F.) will also be sufficient, he says, to bring down the axillary temperature permanently after a short elevation. Senator arrives at the conclusion, based upon his experiments, that constancy of the temperature within the axilla and also in all other parts of the body under the same conditions, only takes place within very narrow bounds at the ordinary temperature, these limits being much narrower and, at the same time, situated much higher in the range than we are usually in the habit of supposing. The range according to Senator is at the very most 8° to 10° C. only, within which the body—certainly without external assistance—is capable of carrying out such a regulation that its own internal heat remains a constant one. Undressing in an ordinary room temperature then is, according

to this author, sufficient to disturb the balance of heat. It follows from this that the body temperature can be very effectually influenced by clothing.

'When we are in our clothing,' says Pettenkofer, 'we are in the same condition as we should be if we were naked in a pacific atmosphere at a temperature of from 24° to 30° C.' (75·2° to 86° F.)

My experiments also of testing the temperature of the layer of air between the skin and the clothes, under very different external temperatures, show that, at fluctuations in the temperature of the surrounding medium up to 30° C., the heat inside of the clothing only alters within the comparatively very narrow limits of a few degrees over the greater part of the surface of the body. The temperature of the separate climatic region between the skin and the clothes therefore, is a much more constant one than we at the first glance might suppose, judging by the great difference of temperature between the blood and external heat. As a general rule, the temperature of the blood is only by 5° to 8° C. warmer than the mean warmth of that layer of air which directly touches the surface of the body when clothed appropriately. The temperature of our separate climatic region—the layer of air between our clothes—depends on our own will. We voluntarily increase the covering which is to prevent the escape of our body heat by means of thicker layers of clothing, which may be also of closer texture. 'Man owes his relative constancy of temperature,' says Samuel, 'alone to the great apparata of clothing, habitation, artificial heating by fires and stoves, and voluntary movements.' He therefore rightly lays stress upon 'the necessity for placing at the head of the list of all conditions subservient to the maintenance of life that of warmth, which is even more important to be attended to than nourishment itself. The greater portion of human labour is devoted, directly or indirectly, to keeping up the constancy of the temperature. When we boast of the wonderful property possessed by man of keeping up his body temperature, alike when in the polar regions or in the tropics, we do so having made a long series of silent presuppositions. Man is obliged in order to maintain his temperature to partake of little, which must at the

same time be cold when in the tropics, and when at the north pole he must eat of that which is fat and heat-productive; whilst his clothing in summer must be light and a good conductor of heat, it must in winter be heavier and non-conductive. His place of abode must be heated in winter, in summer it must be kept cool and shady. In cold weather he must keep in active motion in the open air, but in summer he must avoid every exertion, otherwise we can be accountable for nothing; and it may happen—indeed, it not too seldom does happen—that his limbs become stiff in winter and that he completely freezes, or loses his life by sunstroke in summer. In other words, our much admired normal temperature is only an artificial production which requires to be carefully generated and cared for. The fact that we have successfully managed to turn our natural deficiency, the congenital want of protection against cold, into a peculiar superiority of man over animals by creating artificial protection according to his solid requirements, does not alter our condition in the slightest, so long as we avail ourselves of this protection more or less. It is that necessity of life, the maintenance of the body heat, which has necessitated personal clothing, the permanent appropriation of things of the external world for our own person, and thereby, the beginning of private property even under the most primitive conditions of estate. The differences in the magnitude of this necessity of life form the existing most radical and instructive varieties of character between the people of the globe.'

It must be our endeavour in physiological as well as pathological investigation to fathom the physical nature of individual processes. Similarly our endeavours in therapeutics must be directed to the explanation of our results by directly physical actions in order to reduce them to the lawful principles of natural science, and not attribute them to mere accident. Heat is one of the most essential conditions for the manifestation of the vital phenomena, and its origin is referable to vital chemical and physical processes. Local as well as general vital phenomena are bound down to a certain degree of temperature. Local and general temperatures which are either too high or too low will cause very profound alterations of the local as well as general nutritive and

metabolic conditions. Lowering the temperature locally or generally will, upon the whole, delay tissue metabolism and slacken the cell formation or prevent it altogether. Cell life, cell proliferation, cell division, and cariocynesis are all delayed by cold. *The reverse may generally be expected from an elevation of local or general temperature.* The questions under discussion then will be, to show whether we can alter the local or general temperature by local or general cooling down or warming, and whether, by means of our interference, we can overcome those processes—which have yet to be discussed—which keep the body and its individual parts at an equal temperature and, in a measure, protect it against attacks by climate and temperature. We must, first of all then, show that the physical laws also apply to the living animal organism, and that we are able to alter the temperature of the body and its parts just as we please either by depriving it of heat or increasing the heat supply.

There is, firstly, no doubt that media of different temperatures coming in contact with the warm-blooded living animal body endeavour to place themselves in a condition of thermal equality with it. Therefore, when we bring a colder or warmer medium in contact with the warm-blooded living animal body, the latter will either give up heat or take it up; it will, in fact, be either cooled or heated. This incontestable fact has called forth the most perverse contradiction, opinions thereon still being diametrically opposed when the question is asked, What alterations of temperature in the interior of the body and in the deeper structures acted on will be produced by heat and cold? The human or animal living body is, namely, less cooled down by cold and less heated by warmth than would correspond to the simple physical conditions of the media touching each other. The effect of heating and cooling down is, in the living body, not such a one—as might be expected from the measure of the physical conditions of temperature and size of the body alone—as it would be in the case of a lifeless body. Who, in children and adults whose hands had been exposed for a long time to the most extreme degrees of cold, has not seen the hands become subjectively and objectively warm—ay, even burning hot? Suppose you were to bring a piece of ice in contact

with the body, you would never—no matter how long the parts remained in contact with each other—be able to bring about a complete balance of temperature between them so long as you did not destroy the life of the particular part. The living part will always have the higher temperature, and remain so, the heat-abstracting medium the less. Heat another part of the body by means of poultices or hot fomentations, and you will find that there always exists a difference in temperature between the warming substance and the superficies of the body so long as life is not completely extinct, and the part of the body will be of a lower temperature than the heat-conducting agent. *Hence we must maintain for the living animal organism that it possesses the capability of being warmed and cooled down.* Let us consider, for instance, parts which are exposed to extreme thermal influences more closely, and we will observe a part at one time high-coloured and somewhat swollen; we at once recognise that the blood supply to it has become increased, that all the vessels are dilated, and that the part is more succulent. Very often, however, we will find the opposite phenomenon. There are individuals in whom it is impossible, notwithstanding that an adequate heat supply has been kept up, to restore the natural heat to the part for hours after cold has been allowed to operate upon certain peripheral regions for a period of longer or shorter duration. These usually peripheral parts have a deadly pale colour; they are as though shrunken, objectively cold as marble, and cause in the subject a feeling of tension and drawing together which may become even painful. Thus we find cold at one time producing direct redness and dilatation of vessels, causing congestion and fluxion to the organ affected by the stimulus, whilst the same stimulation at another time is followed by an intense vascular contraction or spasm, which can almost completely check the circulation in the affected part. In the first case redness, succulence, and warmth appear in the parts subjected to the cold, either during its application or shortly afterwards; in the other the part remains for some time pale and cold, and the arterial spasm continues even at a high temperature, so that disturbances of nutrition follow—as in complete suspension of the circulation—

and there may be even dry gangrene of the parts in extreme degrees of contraction.

But heat also is able to cause arterial spasm, although less often, yet it mostly causes dilatation of the vessels and acceleration of the circulation. If we bear in mind the action of these circulatory conditions upon the local temperature, we will be able to understand why, when an adequate influence is allowed to act upon the blood stream, cold sends down the local temperature much less than the physical conditions require, and why heat elevates the temperature much less than it ought to according to the same physical conditions. We see therefore, that the temperature of each individual part of the body is directly dependent upon the circulatory conditions, dependent indeed to such a degree that the local temperature is controlled much more by the activity of the circulation than by that of the media surrounding it.

With every wave of blood conducted to the part required to be cooled down, a wave of heat is conducted to it as well; this wave of heat compensates for a part of the heat abstracted by the cooling medium, it prevents the too rapid sinking of the temperature of the tissues affected, and, furthermore, it prevents the cooling process from extending too deeply towards internal organs. As soon as the blood wave has given off a portion of its heat, it returns to the internal organs well cooled and makes room for a new warm blood wave, from the heart. The opposite *rôles* will be undertaken by waves of blood and heat when there is peril of over-heating the body as it comes in contact with higher temperatures. In this case the blood wave with its comparatively low temperature will act as a cooling agent, and will conduct a part of the heat applied from the affected part, distributing it over the whole organism and thereby lessening the local injury ; by simultaneously increasing the discharge of heat at other points or by other collateral means it diminishes the danger of over-heating. This is one of the physiological processes which delay or check the too rapid penetration of cold or heat to the inner organs. The vascular spasm too, which was described as resulting from cold and which completely checks the circulation in a cooled

organ, belongs to the list of safeguards which the body possesses against the attacks of temperature. Organic tissues in themselves are bad conductors of heat; organic fluids however conduct it somewhat better. If now, a good conducting fluid be caused to circulate close to a cooling body, it must be cooled down by the latter and returned to the inner organs at a lower temperature, and cool them down also. Should however the circulation be suspended through arterial spasm, the heat-abstracting medium will only cause a local reduction of temperature by obliquely carrying away some heat through the badly conducting tissues. The blood stream does not come into direct contact with the heat-abstracting medium; it is protected from loss of heat by the arterial spasm.

Local Refrigeration.—Local Elevation of Temperature.

From the experiments of numerous investigators we gather that we are in a position to control the local temperature of a part of the body at will into the very depths of the tissues, by means of the local application (of which we shall speak first of all) of different temperatures. Esmarch, in particular, has shown beyond doubt that by cooling down of peripheral parts of sufficient duration we are able to lower their temperature down in the very cavities of the bones by many degrees, whilst Schlikoff showed that we can produce powerful alterations of temperature in the depths of the trunk and in the organs therein situated, by acting from the upper surface of the body. The process in a local cutaneous refrigeration may perhaps consist in a primary anæmia of the skin and a collateral reflex hyperæmia, brought about through the nervous system in the muscles situated beneath the part cooled down. This muscular hyperæmia prevents a too rapid penetration of cold to the inner organs by increasing the supply of warm blood; probably also by the increased formation of heat there and then, which signifies increased local tissue metabolism, and protects the organs up to a certain degree from extensive cooling down. From this process also may be deduced, in the simplest and most natural manner, all the phenomena of the so-called reaction against and following cold impressions.

Summed up then, cold and warm local applications bring about—

1. A cooling down or warming of the surface of the part brought in contact with the thermal medium, which, if the application be of sufficiently long duration, will make the temperature almost the same as that of the medium in contact. The surface temperature always remains somewhat higher, no matter how intense the cooling down as long as it does not destroy the vitality of the part; and in like manner it remains somewhat lower when applying heat, provided this is not excessive and incompatible with life.

2. Local refrigeration and heating do not alter the general body temperature, or at least only inconsiderably, even after very prolonged action, provided the region of application does not amount to a quarter of the superficies in extent.

3. Every part of the body, no matter how deep, may be thoroughly cooled or heated either by refrigeration or heat supply of sufficient duration.

4. Heating and cooling down, after reduction and elevation of temperature, follow all the more rapidly the higher or lower the surrounding temperatures are after the thermal interference.

5. The intensity and duration of heat abstraction and heat supply stand, the former in direct, the latter in inverse proportion to the promptitude and degree of the following reaction.

6. The bearing also, after thermal interference, is of influence upon the more rapid or gradual appearance and extent of the reaction. Active and passive movements of the particular part bring about more rapid refrigeration or recovery of warmth than rest.

7. Individual conditions, particularly of innervation and circulation, are of great influence upon the reactionary processes after thermal interference.

8. In local heating the surrounding parts become cooled down; in local refrigeration the surface becomes warmer—symptom of altered heat distribution.

We already know that cold and heat locally applied influence the innervation and circulation in a definite manner.

The local alterations of temperature of the tissues will also be of great influence upon the local processes of nutrition.

Metabolism is delayed in the cooled tissues and accelerated in the heated ones, as has been already pointed out above.

Inflammations run a considerably slower and milder course in the cold; this has been experimentally proved by Samuel. The inflammatory phenomena are checked in their development by cold, partly through the slackening and lessening of the blood stream, partly also by the reduction of temperature itself.

The chemico-physical and the ultimate vital processes are always bound to a certain temperature; they are delayed by cooling down, perhaps in some respects quite suspended, and are certainly promoted by elevation of temperature. Experiment teaches us that the process of diffusion between fluids chemically different and endosmosis and exosmosis, undergo the greatest changes after alterations in temperature according to *quale* and *quantum*. Exudation and suppuration decrease in the cold, the pus becomes thinner, more serous, and poorer in pus cells. *On local heating suppuration becomes more profuse, and the pus will be richer in cells.*[1]

Esmarch has drawn attention to the lessening and prevention of chemical decomposition, and the delay and avoidance of fermentation and putrefaction in the cold and their acceleration by heat; also to the significance of these facts for the treatment of wounds, ulcers, and zymotic processes.

[1] The importance of this pathological fact is utterly ignored, even at the present time, by the numerous surgeons who at once apply a poultice when an inflammation begins to make itself apparent. The late Professor Hueter's dictum, 'that the poultice had disappeared from surgical practice,' will require a long time to become a *fait accompli* in Great Britain; although it must be evident to the veriest tyro that resolution of an inflammation must be infinitely preferable to termination in abscess, which will be the natural consequence of poulticing. Perhaps the dread lest the lancet might no longer be required and Othello's occupation thus be gone, deters many otherwise so brilliant surgeons from accepting the inevitable and renouncing that old woman's remedy, the linseed meal poultice of our ancestors. Let it however be well understood that this does not apply to the cases in which warm applications are indicated, amongst which, of course, the poultice may find a place; they are sufficiently treated of in the text further on to render a digression as to their merits in medical or surgical practice here unnecessary.—TRANSLATOR.

The acceleration of tissue metabolism during the reactionary period following local temperature reduction, and its slackening after elevations of temperature, will also find therapeutical application and estimation.

General Refrigeration and Heating.

That which has been said concerning local cold and warming influences—namely, that they finally succeed in overcoming the local automatic opposition of the living body to interference by temperature—is also true concerning attacks upon the general temperature.

The protectives acting automatically against general lowering of the body temperature consist in—

1. A falling of the temperature of the surface of the body. By this means is caused a lessening of the heat tension between the skin and the heat-abstracting medium in contact with it; therefore, according to physical laws, the loss of heat is diminished.

2. Limitation of the cutaneous circulation. A collateral hyperæmia of the layer of muscles enveloping the whole body is the result of this; whereas the former is followed by a lessened loss of heat, the muscular layer, which is richer in blood and therefore also warmer, prevents too deep and facile penetration by the cold to the internal organs.

3. The temperature elevation of the muscular layer, which is recognised by the rising of the axillary temperature during heat abstraction, is caused by thermal reflex in addition to collateral hyperæmia. Whilst cold impressions call forth a contraction of the cutaneous vessels, their influence, as is proved by the experiments of various investigators, appears to consist in a dilatation of the muscular vessels.

4. This increased quantity of blood in the muscles appears also to give rise to an elevation of the heat production within them.

The most powerful safeguard against very rapid penetration of the cooling process to the inner organs is this heat producing muscular layer which stores up the heat as a bulwark, encompasses the intestines, and, itself a very bad conductor of

heat, is in addition covered by the badly conducting, bloodless skin.

The safeguards which act automatically against impression by heat are—

1. Dilatation of the cutaneous vessels and acceleration of the circulation through the skin and subcutaneous cellular tissue.

As soon as a medium which is warmer than either skin or blood comes in contact with the surface of the body, the cutaneous vessels become dilated, the circulation in the skin is accelerated, and secretion by the dermal organ set a-going. Thereby the giving-off of heat by the skin is in the next instance increased, the blood-warm sweat which is deposited upon the surface of the skin will evaporate under favourable conditions, and in this manner deprive the body of great quantities of heat.

The blood circulating in the skin is cooled by the sweat secretion and evaporation, and therefore returns with a lowered temperature to the inner organs to prevent their over-heating.

2. If the action of the heat be carried on still further there will be a large quantity of blood retained in the skin through the loss of tonicity of the cutaneous vessels, the cutaneous circulation will be slowed, and the blood which was warmed at the surface will thus be prevented from returning to the inner organs and heating them.

3. Through the increased accumulation of blood in the skin a diminished quantity of blood only remains in the inner organs; their activity is lowered, and with it the production of heat as well.

In all these processes a protective mechanism against the too rapid penetration of heat to the internal organs, and against a too rapid elevation of the body temperature by caloric influences, is to be sought for, and it consists in the *automatic defence* which the living animal organism offers to heat.

Quantitative Estimation of the Magnitude of the Heat Loss.—Heat Regulation.

It must have become apparent to us, from even this theoretical consideration of its importance, how great a part the

cutaneous circulation must play in the resistance of the body to cold and heat. *Only a quantitative investigation however into the difference in the amount of the heat given off, according to the altering circulatory conditions of the skin, could give us any idea of the real significance of the cutaneous circulation for the heat economy of the body.*

I have made an attempt to ascertain the amount of heat given off directly by the skin; the principle upon which I undertook *to find out the amount of the heat lost by the surface of the body* was, *the measurement of the amount of heat which the skin had to give off in order to warm a quantity of air of known volume within a certain time.*

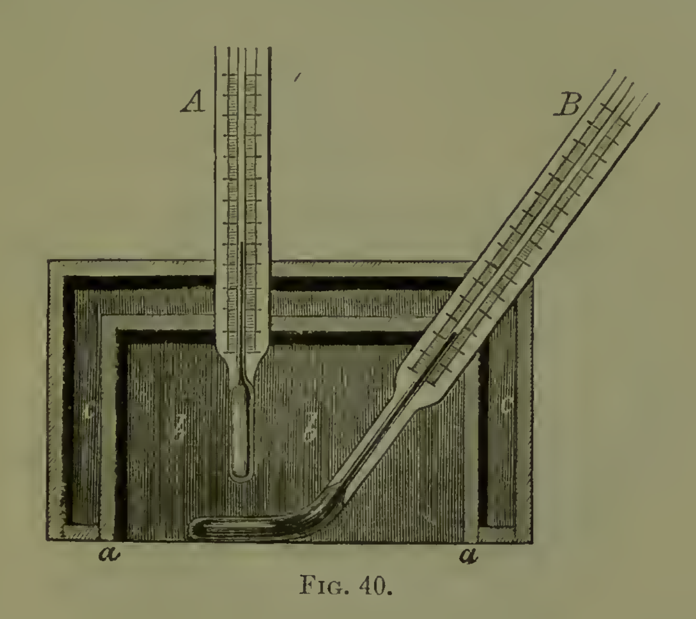


Fig. 40.

For this purpose I had two wooden boxes constructed with double walls separated from each other by an air-containing space of 6‴, as air is a very bad conductor of heat (see figs. 40 and 41). These boxes of cube form, enclose by five sides an air space of 50 c.cm. in volume. The sixth side, which at the same time forms the base of the box, is open. Piercing the double walls of the box, two thermometers are inserted by their bulbs into the cubical air space. The vertical thermometer (A) is fixed so that its cylindrical mercury holder ends 4‴ above the level of the open surface of the air space. The second thermometer (B) possesses a mercury holder which, from the scale down, is bent off at an obtuse angle, and is then coiled up like a snake, the coils lying on the same level; this thermo-

meter is somewhat movable up and down. The square entrance to the cubical air space enclosed by the four double walls (a) measures exactly 15 □ cm. In order to prevent the results from being disturbed by the evaporation or condensation of perspiration or transpired water, I cover the open side of the air space with an impermeable membrane of the very finest guttapercha tissue, numerous control experiments having convinced me that such a covering when closely applied to the skin at every point does not materially alter the radiation of heat—it may perhaps, on the other hand, increase it by a small amount. This harmonises with the fact, discovered by Laschkiewitsch, Edenhuizen, and others, that impermeably

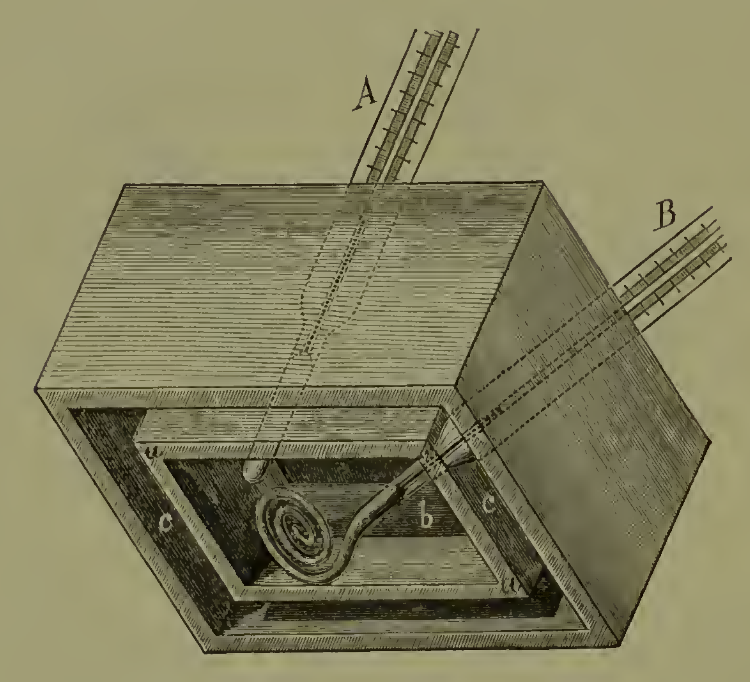


Fig. 41.

covering the skin or varnishing it, will elevate the radiation of heat considerably.

The application of the apparatus just described is now as follows :—

The temperature of the room and of the air space of the box (which for the future we shall call the calorimeter) having been taken and noted, the calorimeter is so placed upon the skin that the guttapercha membrane everywhere lies evenly upon it. The whole calorimeter—which, in order to lessen the radiation and to better isolate its air from the

surrounding temperature, it is advisable to cover with different layers of bad conductors, e.g. cotton wool, flannel, and silk—is then rapidly strapped by a girdle to the part of the body whose heat radiation it is intended to test; finally the thermometer with the coil is pressed down upon the skin by pushing it gently forward. At certain definite intervals the warming of the cubic air space is now read off the vertical thermometer and noted. At the close of the experiment the temperature of the cutaneous surface which was tested may be read off the coiled thermometer.

Since the content of the cubic air space of my calorimeter is a known quantity, and the temperature of the air within it was noted before placing the apparatus upon the skin, and since also the air space has a measured base of regular form, it is possible to calculate approximately from the observation of the heating of the air space how great was the amount of heat given off by the tested and measured cutaneous surface.

If I now wished to ascertain whether any impression upon the skin would cause an alteration in the amount of heat given off by that organ, I made an impression after the removal of the first calorimeter with which the radiation from the skin had been estimated previously, and now placed a second calorimeter, prepared in the same manner as the first before commencing operations, upon the identical cutaneous surface, so as to estimate renewedly the amount of heat given off. In the course of other experiments I have simultaneously tested, on symmetrical parts of the body, the heat discharge from a portion of the cutaneous surface in a normal and in an abnormal condition respectively; comparative results were thus arrived at.

The attempt to test the influence of the circulation in the skin and of the blood contained in it upon the discharge of heat, succeeded with this apparatus. The blood was driven out of some part of the body by means of Esmarch's bandage for this purpose, and one calorimeter placed on the bloodless limb whilst another was placed upon the corresponding limb of the other side, the circulation of which was not interfered with.

A great difference now showed itself between the amounts of heat given off by both these limbs. In like manner, the

influence of venous stasis within the skin upon the heat discharge of that organ was tested in other experiments.

Other experiments demonstrated the influence of the dilatation of the cutaneous vessels by mechanical or chemical stimulation upon the heat discharge, and finally, the action of thermal impressions upon the heat discharge from the surface of the body was investigated. It was then shown that, from a cutaneous surface of equal size on the side from which the blood had been expelled and to which the blood supply was limited, the discharge of heat was lowered by about 23 per cent. when compared with a cutaneous surface of equal size with normal circulation. In such a case then, 50 c.cm. of air will in ten minutes be 1·2° less warm on a cutaneous surface of 15 □ cm. —this being the size of the base of the air space of my calorimeter—when the circulation is obstructed than when it is intact.

Let us assume that the cutaneous surface of a man weighing 82 kilos. has become bloodless all over to the same degree, as an approximate calculation may be arrived at in this way. According to Valentin the whole superficies of an individual of this weight would be about 1·65 □ metre = 16,500 □ cm., or 1,100 times 15 □ cm., which is then 1,100 times the base of my calorimetrical air space. At a mean heat capacity of the air of 0·237, 1,100 × 50 c.cm. = 55 litres of air, would be heated 1·2° less than when the circulation remained undisturbed.

By expulsion of the blood from the whole skin there would be a saving in heat within ten minutes of 1·2 × 55 × 0·237 = 15,642 calories. The heat production of a man of mean body weight is calculated at 1·8 calories per minute; hence he must in ten minutes produce 18 calories. By expulsion of the blood from the skin then, there would be 89 per cent. of the mean amount of heat normally produced retained within the body by the diminution in the loss of heat caused by this expulsion.

According to the numerous experiments which I have in this manner carried out, the alteration of heat discharge by blood expulsion and suspension of the circulation in one part, fluctuates between 10·5 and 25·6 per cent. Only by means of the mechanical expulsion of the blood from a part of the body, and by obstructing the blood supply to the part, was it possible to

obtain comparable figures for the heat discharge during intact or almost completely suspended circulation. Only in this way, which I was the first to enter upon, could the significance of the circulation to the amount of the heat discharge in the living human being approximately be ascertained. I also succeeded in this way in discovering that venous stasis in the skin could cause a reduction in the amount of heat lost of from 18·5 to 46·9 per cent. below the normal amount.

Calculated for the whole surface of the body, there would be (according to this) in ten minutes 16·945 calories retained within the body in universal cyanosis, or, at a mean heat production of 18 calories in ten minutes, there would be 94·14 per cent. of them retained within the skin by stasis.

The cutaneous circulation, when influenced by mechanical and chemical stimulation, was tested by me also as to its influence upon the heat discharge; and it appeared in these experiments likewise that every dilatation of the cutaneous vessels, and acceleration of the circulation thus caused, was connected with a corresponding increase in the heat discharge.

I was able to ascertain that in thermal impressions the reduction in the heat discharge under cold influences was a very considerable one; indeed, a much greater one than could be obtained even under the expulsion of blood from a limb. After cooling the cutaneous surface of the body the reduction per cent. in the heat discharge amounted in the different experiments to between 35·8 and 55·4 per cent., which might correspond to a retention of heat over the normal of from 29·7 to 59·832 calories. The influence which such a diminution or increase in the heat discharge must have upon the circulation may be gathered from the following calculation :—

According to the most reliable accounts, the mean heat discharge from the whole surface of the body of a man weighing 82 kilos. will be from 2,092 to 2,592 calories in 24 hours, being from 83 to 108 calories per hour. A reduction in the heat loss of from 10·4 to 25·6 per cent., as is caused by the mechanical expulsion of blood, could therefore cause the retention within the body of from 8·6 to 27·6 calories in one hour. In venous stasis within the whole skin the reduction of the heat loss might amount to from 14·94 to 50·652 calories. When cooling down

the cutaneous surface 29·7 to 59·832 calories could be retained within the body.

On the other hand, a mechanically or chemically induced dilatation of the cutaneous vessels might signify an elevation of the heat loss over the normal up to 99·792 calories.

In order to raise the heat of a body weighing 82 kilos., with an approximate heat capacity of 0·83, by one degree, a quantity of heat amounting to 68·06 calories is required. Hence the temperature of the body would have to rise one degree, in expulsion of the blood from the skin, within $2\frac{1}{2}$ hours; in venous stasis, in less than $1\frac{1}{2}$ hour; after cooling of the surface of the body, in less than $1\frac{1}{4}$ hour, by retention of heat, or, in the same time, be able to compensate a lowering of temperature by 68 calories, the heat production being quite unaltered. The dilatation of the peripheral vessels could, by giving off more heat, lower the temperature of the body by one degree indeed in $\frac{3}{4}$ of an hour; or, in other words, the activity of the skin can neutralise so great an elevation of the body temperature as this, in the time named. If we might apply the diminution or increase of the heat discharge actually observed in any portion of the body to the whole of it, there would be still larger figures showing the heat-regulating function of the skin. The numerals calculated simply cannot be the expression of the utmost range of operation of the skin function. If the maximum of the actually observed diminution and increase of the heat discharge might be applied to the whole surface of the body, the resulting factors would about show, that the skin function would be able to compensate the normal mean heat loss $3\frac{1}{3}$ times if pushed to its greatest possible activity, and that, on the other side, it would be able to increase the mean normal heat loss by $3\frac{1}{2}$ times its own magnitude.

The dermal organ, it would seem then, is to a certain extent prepared for abnormally great strains upon its function. It is quite easily imaginable that this power of altering the amount of the heat loss is capable of keeping up the constancy of the body temperature even under those alterations of the heat production which certainly do occur. According to our former explanation then, the possibility exists for example, *that by increasing the heat discharge we are able to compensate*

for an increase in heat production of 3½ times the normal amount. In order to keep the body temperature constant under the ordinary conditions of cooling or warming, it is not necessary for the skin function to put itself to any extreme strain.

A slight per cent. diminution or increase of the heat discharge will mostly suffice to keep the temperature constant or quickly to restore its balance. It is also easily understood that, under circumstances, in order to guard against a cooling down or over-heating of the body, it is not necessary for the entire dermal organ to enter into action. The fact that we very often find differences between the heat discharge of individual parts of the body, which may amount to 30 or 40 per cent., certainly points to this. It is for this reason that the diminution or increase of the heat loss observed in one or other parts of the body is not to be applied in a mathematical sense to the whole dermal organ.

We have furnished the proof by our experiments that *an alteration of the discharge of heat, even from only one part of the body*, is not only capable of keeping up the constant temperature of the body, but also of altering it. *As certainly also must it be a function of the central nervous system which, put in motion by reflex through sensory nerve endings, governs the calibre of the peripheral vessels, the rapidity of the current in them, and thereby also the amount of the heat loss.*

I was enabled to recognise the exactitude of the regulation of the heat discharge by the skin through experiments in which I voluntarily increased the heat discharge from one portion of the body surface. There regularly appeared a diminution of the heat discharge from some other part of the body. Here also, compensatory processes display their activity ; indeed they are proved to play a most important part in the whole heat-regulating apparatus. Contraction or dilatation of the vessels of only a portion of the superficies of the body will act as a very effective regulator of the body temperature.

The significance of cold hands, cold feet, a partial or a complete rigor for the temperature constancy of the body and for the heat regulation, will now dawn upon us ; they are the expression of the covering of the heat deficit by a saving in the loss. The explanation of many pathological temperature elevations by

retention of heat and diminished heat loss has found a correct basis in our experiments.

If we can call to mind once more that, according to my experiments, the amount of the heat discharge can fluctuate between more than 60 per cent. downwards and more than 90 per cent. upwards, we can understand what significance ought to be attached to the skin function in the heat-regulating economy. *Within the limits wherein constancy of the body temperature takes place, this can only be explained by alteration in the heat loss.*

By this it is by no means implied that the heat production may not also fluctuate. Practically, however, the quantitative examinations of the end-products of tissue metabolism furnish us with sufficient data whereon to found such an assumption.

Semeiotic Significance of Heat Retention.

From these experiments, however, we have learnt the practically important fact *that a diminution of the heat loss is of itself capable of producing febrile elevations of temperature.* It will be intelligible to us now why very rapid defervescence, or at least subsidence of the febrile temperature elevation, should follow an increase of the heat loss. Hence our next duty will be to deduce the value of such investigations for the enlargement of our pathological knowledge and rational therapeutic activity. Diseased conditions which may be expressed by increased or diminished heat discharge, diseased conditions whose anatomical basis is found in contraction or dilatation of the cutaneous vessels occur often enough, and, when properly interpreted, they can be remedied with almost physical accuracy by means of thermal and mechanical influences.

In this direction very important problems fall to the lot of hydrotherapeutics, the prompt solution of which has elevated this method to the level of a very powerful healing factor.

If in diagnostic relation, an exact method of examination has been found by testing the distribution and discharge of heat, for judging the irritability of the cutaneous vessels, the condition of the nervous system, of the heart's action, and threatening collapse, there will be many therapeutical indications established by it also.

In the beginning or course of febrile processes we often succeed in recognising heat retention as one of the causes of febrile elevations of temperature, and Traube's opinion is thereby confirmed.[1] The corresponding hydriatic procedures, as we shall learn in the next chapter, will assist us in reducing such temperatures with certainty.

When in acute and chronic diseases an unequal distribution of heat and blood obtains, this will often be recognisable with accuracy only by temperature measurements of different parts of the body and estimating the heat discharge from different cutaneous regions; we will then be able to take the necessary measures for its prevention. By cutaneous calorimetry was the *modus operandi* of derivative procedures and such as alter the distribution of the blood, first made clearer to us. The same applies to the retardation of rigor by hydriatic measures, and in many cases it is possible to obtain an effective reduction of temperature by these measures alone.

I have succeeded in showing that febrile elevation of temperature also is capable of finding in an increased heat discharge a compensatory action.[2] We must admit therefore, that the knowledge of many pathological processes as well as hydrotherapeutics itself, has been promoted somewhat by my calorimetrical investigations.

Many investigators, through not making allowance for the alterations in the heat loss according to the conditions of the cutaneous circulation, arrived at the result that during the action of an unusual withdrawal of heat upon the exterior of the body, the temperature of the interior did not undergo any reduction but rather became elevated. This will however be only the case when the contraction of the cutaneous vessels thermally achieved, has not been interfered with; as soon as proper attention is devoted to the circulation in the skin, it will be possible to attain a reduction of temperature internally even with what may be considered—from their duration and intensity—very moderate heat abstractors. Some investigators arrived at the incredible result that an abstraction of heat brought about an

[1] S. Winternitz, 'Ueber Wesen u. Behandlung d. Fiebers,' *Wiener Klinik*, 1875, and *Hydrother.*, vol. ii. p. 230 et seq.

[2] Winternitz, *Hydrotherapie*, vol. ii. p. 255 et seq.

elevation of the body temperature, through having observed the increase of temperature at one or other part of the body during the cooling-down process. We already know that this behaviour of the temperature need not necessarily be dependent upon an increase of the heat store within the body, but that it may owe its origin to an unequal heat distribution brought about by abstraction of heat, and that it is principally caused by collateral hyperæmia.

The most striking proof of the correctness of this view I have brought by showing, *that two baths of quite equal temperature and duration, under other conditions as equal as possible, brought about in the same individual once an elevation of the axillary temperature whilst the rectal temperature remained the same, and at another time called forth a considerable sinking of the warmth in both these parts.*

In the first instance, thermal cutaneous contraction was not prevented, and in the second it was released during the cold impression by powerful friction over the surface of the skin.

From this we learn for practical purposes that when we wish to lower equally the general body temperature, we must take the trouble to quickly release the primary cutaneous vascular contraction during the cooling-down process, or have prevented it *a priori.*

Thermal Influence upon the Heat Production.

It will scarcely occur to any one to deny that *in abstractions of heat from the external surface of the body the production of heat will also show variations.*

It is a physical necessity that when a body has been deprived of heat and regains its former temperature after some time, it must have during this time either produced more heat or, by a diminished heat loss—that is, by saving of loss—have reached the former degree of temperature. If we in any way prevent this saving of loss and the body heat still returns to its former height, then there has been more heat generated during this period. Almost the whole of the heat of the body, at least the greater part of the organic heat, is formed

in voluntary muscle, as has been more particularly shown by Samuel's interesting experiments, a tissue whose mass forms nearly a half of the whole weight of the body.

By the operations of cold upon the exterior surface of the body there must evidently be an increased heat formation in all the muscular structures, since the muscles are placed in a condition of heightened tonus by cold and sometimes driven even into spasm, which may increase to a general spasmodic quivering—the rigor. With muscular contraction however, heat production also occurs ; the apparently inactive, simply tonic muscle also produces heat; this belongs to its normal function. A muscle placed in a condition of heightened tension by the cold bath will produce a greater amount of heat. As long as the temperature within the muscular layer remains elevated in heat abstraction from the surface of the body by collateral hyperæmia and reflexly heightened innervation, so long will there be here a manifestly increased heat formation ; and it is certainly not to be denied that this increased heat formation is a powerful factor in the regulation of heat and the temperature constancy. This however will only remain the case so long as the cutaneous vessels are contracted, the cutaneous circulation limited, and direct refrigeration has not yet penetrated through the tissues to the muscular layer. An actual lowering of the temperature of the muscle itself will here, as in all other organs, lower the organic function and reduce the heat formation ; indeed, it is capable of entirely suspending it, as numerous experiments have proved. The stimulation to increased heat formation within the muscular layer in heat abstraction, proceeds also by reflex from the peripheral sensory nerve endings. So soon as these are touched by a cold stimulus, they signalise the danger of cooling down to the centre, and this at once, by reflex on vasomotor tracks, makes provision for preventing the cold from penetrating to the inner organs by dilating the muscular vessels, elevating the temperature of the muscular layer, and causing an increased heat production within it. Should however the contraction of the cutaneous vessels be prevented, the peripheral sensory nerve endings will be bathed by constantly renewed waves of blood at the tempera-

ture of the heart; they are less intensely stimulated by the cold irritation under such circumstances, and, on account of the great amounts of heat conveyed to them, they are not cooled down thereby. Hence they will conduct less important impulses to the centre, deliver less powerful reflexes, and incite the muscles to diminished tension and lessened heat formation.

Now we can conceive how it is *that the absolute amount of the heat abstraction does not fix the amount of the heat production, but that it is fixed by the magnitude of the thermal nerve stimulation*, the degree of the actual refrigeration of the peripheral sensory nerve endings. It is this which causes the increased production by reflex, and controls its power; this need not always stand in exact proportion to the magnitude of the heat loss. We can now perceive why two baths of equal temperature and duration have such different effects upon one and the same individual. In the one case the peripheral circulation was checked, the periphery of the body cooled down deeply, the peripheral sensory nerve endings stimulated intensely, whilst the reflex heat production in the muscular layer was powerfully increased and a sinking of the axillary and rectal temperatures prevented; in the other case the peripheral circulation was accelerated, the periphery of the body less deeply cooled down, the sensory nerves were less stimulated, whilst the reflex elevation of the heat production in the muscular layer was only minimal, and axillary and rectal heat were caused to sink deeply.

It is now also explicable *why the results of the estimation of carbonic acid in heat abstractions are inconstant; if the excretion of carbonic acid is in direct proportion to the formation of heat within the muscular layer*—and this is quite possible—*it must also stand in inverse proportion to the degree of irrigation of the skin by blood.* Should it be required to estimate the value of heat abstraction in febrile diseases and the favourable results of reductions of temperature in such, from the points just evolved, we need now no more take refuge in artificial, aërial hypotheses and laboured explanatory attempts. The whole process is a very clear one, and even illuminates opposite unfavourable experiences.

If by heat abstraction heat production is increased—as in the case of obstructed peripheral circulation there is no doubt it is—one can rightly say, and it has been said, that the heat, abstracting treatment of fever patients is a highly irrational one, inasmuch as by it the formation of heat, thereby the tissue metabolism, and ultimately the febrile consumption of the body must be increased. It was endeavoured to explain the, in spite of this, often very favourable influences of heat abstraction by proving that the increased heat production during the cooling-down process is followed by a compensatory, indeed, almost a hypercompensatory diminution of the heat production after refrigeration ; this was supposed to explain the sinking of the body temperature after baths. That this fall is only dependent upon the equalisation of the temperatures between the periphery, which was cooled down a great deal more than was anticipated, and the remainder of the body, following hard on the heat-abstracting process —the peripheral blood ways being again opened—I have repeatedly and convincingly shown. If however proper regard is had to the dilatation of the peripheral vessels during the cooling process, the heat production within the muscular layer will be but little or scarcely at all elevated, the blood will give off much heat during the cooling down and not only after it has been concluded ; the temperature of the internal organs will fall during the continuance of the bath and also after the bath, through the increased heat loss by the skin and its dilated vessels. The following consideration further adds to the correctness of this view :—

A rigor is undoubtedly a sign of increased heat production, since a formation of heat takes place with each muscular contraction, the most so when it is spasmodic, as in tetanus, which is a tonic spasm, and in the rigor, which may be considered a clonic one. If it is possible to delay the advent of shivering despite continued and increased heat deprivation, and to remove the shiver when it has already made its appearance as I have shown, that may presumably be taken as a proof that by heat deprivation carried out in an appropriate manner, the tendency to excessive reflex heat formation can be diminished. This proof might perhaps serve for

the correct interpretation of many an experiment in the study of tissue metabolism which apparently teaches the contrary.

If we keep before us the influence of thermal and mechanical interference upon the innervation and circulation, and remind ourselves of their effects upon the blood and heat distribution, and upon the control of the amount of heat production set free by reflex, we will be able to understand that methodical hydrotherapeutics, not alone in the initial stages of febrile diseases and in fevers dependent upon heat retention, but also in fever processes of any kind must be the most sovereign remedy, since none like it when applied appropriately is capable of fulfilling the indications given.

It is possible then to reduce the general body temperature at will by means of heat abstraction, and it has been established by numerous other experiments the enumeration of which would here be too tedious, and which, moreover, are pretty well known already, that by supplying heat, e.g. by a vapour bath, or by diminishing the heat discharge as in dry packing, the temperature of the body can be raised at will.

Alterations of the body temperature such as these, are followed sooner or later by a return to the normal temperature. In both cases however, as well in temperature reduction as in temperature elevation, this return is no simple one; but *following the primary reduction of temperature there is a stage of temperature elevation, and the elevation of the body temperature is followed by a more or less deep declination to the normal.*

This temperature elevation on the one hand and the reduction on the other must, from the constancy of the mean daily temperature depending upon the nervous system, be interpreted as compensatory phenomena and be regarded as an expression of the stability of the heat regulation.

Thermal Influences on Tissue Metabolism.

If the formation of heat within the organism be the end product of the processes of organic life—of metabolic changes —there must, when the body recovers its normal heat after

heat abstraction and consequent lowering of its temperature, clearly have taken place some acceleration of the heat generation and consequently of the tissue metabolism, especially if the return to the higher temperature has taken place without any saving in the heat loss.

The metabolic changes in heat abstraction and heat supply are in many directions still enveloped in a thick mantle of obscurity. It would be most desirable for the rational explanation of the *modus operandi* of thermal influences upon the organism, to fill up, without delay, these gaps in our science. The few facts which appear to have been substantiated hitherto may be summarised as follows :—

Low temperatures bring about an acceleration of the processes of oxidation in the organism, according to the most reliable authorities. The immediate consequences of this will be, an increased excretion of carbonic acid and an increased assumption of oxygen. In impressions by heat there will be lessened excretion of carbonic acid and of oxygen assumption. This increase of the tissue consumption in the cold is (as has been shown by Pflüger and his pupils more particularly) principally a consequence of the stimulation of sensory nerves by the cold.

It seems to be a law *that the greater the thermal nerve stimulation in operation by cold, the more considerable will be, under circumstances otherwise equal, the reflex acceleration of the tissue metabolism.* 'Of itself alone this reflex hyperdecomposition would not be capable of preventing the inhabitants of the arctic regions from freezing, inasmuch as its action is not even sufficient to enable a person to dispense with clothing at a temperature of 25°.' This dictum of Voit's points clearly to the fact that the primary acceleration of the tissue metabolism brought about by cold influences, will not be a very powerful nor a lasting one. The accelerated reflex tissue metabolism excited by the primary nerve stimulation appears, according to the investigations of Hagenbach, Röhrig, Zuntz, and Voit, to concern principally the non-nitrogenous substances. The increased heat formation takes place chiefly in the muscular layer; indeed according to Voit, muscle consumes in its function chiefly non-nitrogenous substances. This harmonises

pretty well with the already described processes taking place within the muscular structure at the moment of the cold impression upon the surface of the body. Quite different, however, will be the conduct of the tissue changes in the organism as soon as the thermal interference has succeeded in really reducing the temperature in the muscular layer. The body whose own temperature has been actually lowered not only may cease to disintegrate, according to all reliable reports, but in any case disintegrates decidedly much less. The tissue consumption is now retarded, and during actual reduction of temperature, there is a retardation of the metabolism taking place. These investigations then may be made to harmonise with our former explanations, and to solve the apparently contradictory statements as to the influence of heat abstraction upon heat production, in accordance with my views. It is nevertheless different with the after effects of heat abstraction ; the empirics long ago knew that every reduction of temperature is followed by a compensatory elevation of temperature after a short time, and during this period the tissue metabolism strongly resembles that in artificial elevation of the body temperature or that of fever.

This reactionary secondary elevation of temperature attains degrees of various height under different circumstances; the lower the primary cooling was, the higher will be, *cæteris paribus*, the temperature elevation, which has been rightly designated by Jürgensen as 'the remote after-effect of baths.' The more rapid and sudden the reduction of temperature has been, the more rapid will usually also be the reactionary temperature elevation; sometimes moreover, after very long-continued methodically and energetically repeated heat abstractions, it happens that upon a very slight provocation cumulative after effects of the baths at last appear, which may cause the body temperature to rise even to a hyperpyrexial point.

Typical febrile phenomena following prolonged water cures, might be included under this heading. The tissue metabolism during the reactionary period or during the remote after effects of the baths seems, analogous to that in fever, to consist in an increased disintegration of albumen. This conclusion is justified by the condition of the urine at

the time of the reactionary temperature elevation after heat abstraction. The urine mostly shows a higher specific gravity in from six to eight hours after the baths, that is to say it contains a greater amount of urea than immediately after the heat abstraction. An increased separation of the urinary constituents, an increase in the amount of the urea, uric acid, chlorides, and other inorganic combinations, has been observed by Kirejeff during the reactionary temperature elevation following heat abstraction.

I nevertheless attach very little importance to these investigations, since we learn in no manner from them in what organs an acceleration or retardation of function is caused. I am under the impression that I can obtain much more certain criteria for the metabolic processes during heat abstraction by observing the behaviour of the body weight, although this method even is not searching enough.

The Bearing of the Body Weight under Thermal Interferences.

When healthy persons who have for weeks displayed almost stationary weight are subjected to heat abstraction once or several times daily, it will be observed that, if the other hygienic and dietetic conditions remain unaltered, especially the *quale* and *quantum* of the diet, a number of these persons will undergo a slight addition to their original weight, whilst the greater number will suffer a reduction of weight thereby. This rule will only hold however, when the habits of life and the the diet are not interfered with. It is a much different matter with the majority of patients seeking a hydropathic establishment for various reasons. I have there found that of 2,400 persons who were weighed before, during, and subsequently to a water cure, the majority (56 per cent.) underwent an increase of body weight, 30 per cent. suffered loss of weight, and in 14 per cent. the weight remained unaltered.

This general result out of a large number of patients affected with the most various disorders, attained too, under comparatively different modes of life, presents not a single point to guide us to the estimation of the *modus operandi* of heat deprivations upon the body weight and metabolism of the

tissues. The above rule, although deduced from experiments smaller in number yet perhaps comparable with others, allows us to obtain a more correct view of the mode of action of heat abstraction upon the tissue changes. Most healthy persons *lose weight, cæteris paribus, under the influence of heat abstraction.* Tissue metabolism therefore, and in particular, retrograde metamorphosis, is accelerated under the influence of heat abstraction. The small number of individuals experimented upon in whom, notwithstanding the equality of other conditions, an increase of body weight was observed, is however most interesting.

Although I was unable to ascertain with scientific accuracy the reason for this increased accumulation by means of exact metabolic investigations, it yet seems to me that the astonishing fact of its existence is worthy of all consideration.

I venture to find an explanation for it in the following theory: When a person who has up to the time manifested stability or even loss of body weight, increases in weight under heat abstraction notwithstanding that all other conditions remain equal, it must be assumed that the substances introduced have been better used up; the formation outweighs the retrograde change. These experiments speak in favour of considering hydrotherapeutics a tone-giving method. The results are brought about probably by heightening the innervation, together with completion of the tissue metabolism and of the most intricate processes of nutrition. An increased accumulation is combined with the increased retrograde changes known to occur during heat abstraction, and metabolism gains in completeness.

How it is that in persons who undergo a water cure an increase of weight is observed in the majority (56 per cent.) is easily explained when we draw into consideration the influence of heat abstraction upon innervation, the movements of the blood and digestion, the result being probably still further supported by the mode of life, exercise, and the enjoyment of fresh air. The stimulation of the appetite and greater amount of nourishment taken in consequence cause the increased accumulation.

I have already pointed out *that the magnitude of the reflex*

heat production brought about by heat abstraction does not depend upon the absolute amount of the heat abstracted, but upon the amount of thermal nervous stimulation combined therewith, as I have proved conclusively in my other work.[1] This reflexly excited increase of heat production takes place predominantly in the muscular layer. Muscular function goes abreast with the combustion of non-nitrogenous constituents of the body.

If, therefore, we wish to lower the body weight by combustion of fat, we must allow the thermal nervous stimulation to act to its utmost intensity, the heat loss being moderately increased. In this manner the greatest reduction of body weight in the corpulent is effected.

Within days or weeks then, it is observed that under appropriate thermal nervous stimulation, there is often a remarkable and rapid loss of flesh, which may be plainly recognised by the scales, *a loss of body weight which takes place in spite of a sufficient administration of food. Reactionary elevations of temperature after heat abstraction also often cause loss of body weight.* In such losses the consumption of the body is one affecting all the tissues more equally. The decrease of muscle is shown by great languor, the nutritive disturbance in the nervous system by sopor, and dulness of the thinking faculty, &c. *Intense heat abstraction with great nervous stimulation and promotion of the reactionary temperature elevation will cause an universal acceleration of the metabolism, a lively retrograde metamorphosis, and the greatest loss in body weight* unless the body is supplied with a considerable increase of appropriate nourishment.

The promotion of the retrograde changes as well as also of the accumulation during water cures is most clearly proved by weighings undertaken during methodical sweat cures. Each individual cure causes a total loss in weight which may reach from 1 to 5 pounds, and at the end of a whole series of such procedures the person under observation generally weighs more than at the beginning of the same.

It is not difficult to make anybody take on or give up flesh at will under appropriate modes of life and nourishment

[1] *Die Hydrotherapie*, loc. cit.

by means of thermal interference. Herein we recognise the great influence of the water cure upon metabolism, and are able to deduce a whole series of indications for this cure therefrom. The most manifold delays in tissue metabolism, the uric and oxalic acid diatheses and corpulency find, for the reasons just stated, a suitable curative agent in the methodical thermal cure; a retardation of pathologically accelerated tissue consumption may also be attained by means of the water cure. Of this latter, the best examples we could possibly select are febrile diseases.

It is proved that during methodical water cures the consumption of the body by fever is less than it would be under other circumstances. The body weight is less lowered and the disintegration of nitrogenised and non-nitrogenised materials is more limited; this is perhaps caused in addition to the reduction of temperature, by the beneficial influence of the water cure upon the digestive processes, as well as the nervous system. The appetite is retained up to a certain degree under the cure, and nutrition does not suffer so much.

The great gap which here also exists in the complete understanding of these remarkable processes must by no means be hidden; on the contrary, the call for further metabolic investigations as an urgent desideratum, may find expression. For reasons which I have often, especially in my 'Hydrotherapie,' laid much stress upon, not even the very latest labours in this field are sufficient.

That which in general the investigations of the various physiologists have taught us attains the climax, I repeat, in the rule that cold increases the excretion of carbonic acid and nitrogen, only so long as the temperature of the body and tissues is not reduced. An actual reduction of blood and tissue temperature lowers the excretion of carbonic acid and of nitrogen. Heat reversely is followed by a diminution at the commencement and an elevation in actual heating of the blood and tissues of the excretion of the end products of tissue metabolism.

We will now cursorily examine the action of heat and cold upon secretion and excretion.

Thermal Influences on Secretions, Excretions, and the Nutritive Processes in the Tissues.

The whole of the processes of secretion and excretion, as well as the vital processes in the tissues and organs, depend in the most decided manner upon the innervation, circulation, general and local temperature, and normal condition of the organ itself. Here it will always be only necessary to investigate accurately the conditions of nutrition in question, and to adapt the thermal actions to these.

Should appearances of nervous depression or irritation be at the bottom of the disturbance of the functions of secretion and excretion or of alterations of nutrition, it will often be possible by thermal stimuli which either directly or by way of reflex heighten or lower the innervation, to cause their subsidence. Diminution or increase of the blood supply, accelerating or delaying its transit, and changing the current more rapidly will likewise sometimes cause the disturbance to subside, increase a diminished secretion, or diminish too profuse a one.

By temperature elevation and reduction as well as by means of moist vapour in which we bathe the diseased organ continuously, we will often be able to remove the disturbance which depends upon an alteration of that organ or tissue.

Finally we are able to operate decisively on the constitution of the blood and the nutritive processes by stimulating certain collateral functions, such as those of the skin and kidneys, or the activity of the liver and intestines. This great and wide territory has however as yet been scarcely entered upon scientifically, although it is often trespassed upon and robbed empirically. In treating of it we can therefore only refer to isolated facts ; it must remain reserved for posterity to penetrate this darkness also by the light of experiment.

Thermal Influences on the Secretory Function of the Skin.

We will now occupy ourselves with the question, What influence can we gain through our thermal interference over the function of the skin, and may we expect that the increased

energy of the cutaneous function will also extend its influence to other organs or disturbances therein?

Besides its function as an organ of sense and feeling, a regulator in the heat economy, and a reservoir for an alternating quantity in blood, the skin possesses no small importance as an organ of secretion and excretion. The exit of carbonic acid and water, of salts and organic substances by the skin is of importance to the constitution of the blood and to the united organic economy. Röhrig has estimated the excretion of carbonic acid by the surface of the body under ordinary circumstances to be 14·076 grms. for the 24 hours, and the amount of water excreted he reckons at 634·44 grms. The total daily loss by perspiration according to this amounts to 648·516 grms. Excretion of carbonic acid and water by the skin however, varies very considerably with the surrounding temperature.

We can conceive that thermal applications must have a powerful influence in this direction, and this all the more surely after it has been proved that these excretions do not cease even on the contact of fluids with the skin. This has been established with certainty particularly for the gas excretion. Since blood contains more water and carbonic acid than the surrounding air, there must be a continuous stream of water and carbonic acid kept up from the blood to the atmosphere, when the blood comes to the surface so far that the epidermis does not offer too great a resistance to this interchange of gases.

By our thermal applications we are in a position to increase the richness in blood of even the most superficial capillary, and by promoting the casting off of the most superficial layers of the horny epithelium, we thin the epidermal partition 'twixt blood and air, and facilitate the interchange of gases thereby. The thermal and mechanical influences of hydrotherapeutics will therefore be in a position to increase the respiratory function of the skin. Many facts also speak in favour of a moderate assumption of gas by the skin, especially the one that the air coming in contact with the skin undergoes changes similar to those it has to pass through in the lungs. The great difference between the tension of the oxygen in the blood and in the atmospheric air, which must cause a diffusion of this gas towards the blood on account of its great chemical affinity for

oxygen, justifies the assumption that the function of the lungs may find some perceptible support in an increase of the skin function, although one that at the present time is inestimable by figures.

Certain it is that the thinnest possible condition of the epidermis, the richness in blood of the most superficial capillaries, and the rapidity of the circulation must also have a decided influence in facilitating the absorption of gases.

Absorption of gas by the skin has been ascertained by animal experiment for the most various volatile substances. This in reality only very lately established fact is of peculiar interest for the reason that it is now considered as quite certain that watery non-volatile solutions *cannot* be absorbed through the uninjured epidermis. The imbibition of a gas of any kind, or indeed of any other substance, seems according to this to depend only upon its aggregate condition. Finely atomised watery solutions of various composition, or such in the form of gas or vapour, will penetrate even the unimpaired skin, as Röhrig, Brémont, and others have proved; and in these facts may perhaps be partially found the explanation of the good effects of hydrotherapeutics in numerous lung affections.

Excitation of Sweating.

In a yet more reliable manner we can regulate, through the skin, the watery constituents of the organism. We can positively heighten the excretion of water by the skin excessively, and we can also diminish it, at will. All stimuli contracting the cutaneous muscles and vessels must necessarily keep back the watery perspiration of the skin, since they diminish the supply of fluids to the surface of the body. In contradistinction to this, everything which relaxes the contraction of the muscles and vessels in the skin will increase the excretion of water by the skin. Hence cold will diminish the watery excretion by the skin at the moment of impression, whilst heat will materially increase it. It is in our power, as we shall presently see, to call forth not alone an insensible watery perspiration of the skin, but also actually to set a-going a powerful secretion of sweat.

Everything which relaxes the vessels of the skin and elevates the blood pressure in the cutaneous vessels, or accelerates the circulation in the skin, belongs to the category of factors favourable to the formation of sweat. An elevation of the temperature of the blood—that is, either retention of heat or increased supply—seems directly to stimulate the nervous centres for sweat secretion.

The amount of sweat which can be produced in a definite time can scarcely be correctly estimated, and depends upon manifold and also individual circumstances. Röhrig quotes that Farre excreted 166 grms. of sweat in one hour; 800 grms. are said to have been caught in a shirt in from 1 to 1½ hour during a sweating cure; Wigand lost nearly 1 pound and 10 oz. in 26 minutes in a vapour bath of 35° to 38° R. (111° to 118° F.); Berthold in 30 minutes 1½ lbs.; Lemonier after a bath of 45° C. (113° F.) in 8 minutes 21 oz.; and Funke gives the amount of watery secretion by the skin in 24 hours as fluctuating between 1,739 grms. and 19 kilos.! The quantity of this excretion being so great, it is of importance to know its chemical composition and properties.

Sweat according to Röhrig's statements, is a clear, colourless fluid of a compound odour, salty taste, and usually acid reaction. The formed elements to be distinguished in it are—oil globules, mucus cells, dark molecular grains, and epidermic scales. On evaporating sweat crystals of chlorides of sodium and ammonium remain behind. Sweat belongs to the most watery secretions of the body, and contains but few solid constituents. The secretion becomes more diluted the more of it is formed under stimulation, hence the differing statements as to the amount of the solid remnants. Besides this the nutriment taken may be of some influence on its constitution.

The soluble salts of the blood form the principal bulk of the remains; they consist chiefly of chlorides, notably that of sodium. Of insoluble salts the principal ones are PO_5, lime, and magnesia; the iron oxide of the sweat is said to depend on the epithelium mixed up in it. The small quantities of ammonium are fixed by hydrochloric, carbonic, and organic acids. Free ammonia could scarcely occur otherwise than as a product of decomposition.

The list of organic constituents of the sweat contains fatty acids, amido, acetic, and butyric acids. The presence is suspected also of propionic, metacetonic, caprionic, and caprinic acids. These acids give the sweat its peculiar odour, which changes under different conditions. Particularly characteristic is a most peculiarly sharp bitter-sweet odour of the cutaneous perspiration, which reminds

one of acetone and chloroform, and which occurs especially in diabetes and different other diseases with rapid muscular disintegration, when it must presumably be always looked upon as a sign of retrograde tissue metamorphosis. The perspiration in certain acute exanthemata, such as scarlatina and measles, has also a peculiar and usually very characteristic smell.[1]

I was likewise often able to convince myself of a very particular kind of odour which proceeded from the cutaneous transpiration of patients with hectic fever.

Since odours only call forth subjective impressions and there has still not been found any method whereby to differentiate them objectively, it is impossible to make use of the varying odours of the sweat in the differential diagnosis of various conditions. This will always remain so much the more difficult since partial *blindness* of smell is even a still more common occurrence than colour blindness. Whilst I myself and a few of my assistants are wont to recognise the presence of a diabetic person immediately upon our entrance into the waiting room, there are others who are completely insensible to this odour. The presence of urea in the sweat has been positively demonstrated by Funke; its amount, however, varies considerably and rises up to a certain limit with the amount of the secretion.

The quantity of urea is much increased in uræmia, cholera, eclampsia, and Bright's disease; sugar is said to have been found in the sweat of diabetic persons. Carbonic acid and nitrogen [2] are also found in the sweat.

Concerning the semeiotic significance of sweating I must here again speak of the heat economy of the body. The insensible perspiration already must bind some heat to the surface of the body through more or less evaporation of water gas, and is therefore a factor in the heat loss. When we recollect that workmen in a tropical climate can excrete from $\frac{1}{6}$ to $\frac{1}{5}$ of their body weight daily by the skin, we can conceive of what an enormous quantity of heat such a great loss of water at the blood temperature will deprive the body, and how much this

[1] The most characteristic smell of typhus should hardly be omitted here. It has been variously described as the smell of mice or hay; but in my opinion it most nearly resembles the odour to be obtained by emptying the contents of a person's bed which has been soiled for some time through incontinence of urine: the similarity of the cause of the odour must be apparent.—TRANSLATOR.

[2] The latter, I believe, has not as yet been absolutely proved to be present. —TRANSLATOR'S Note.

heat loss will contribute towards reducing the elevated temperature to normal again. If the heat loss occasioned by this refrigerating apparatus were wanting, existence in a tropical climate or in over-heated apartments—indeed, the rapid defebrilisation of patients at all—would be totally incomprehensible. Numerically the magnitude of the heat-regulating capabilities of the sweat has certainly not been sufficiently established, and on that account I will not enter into the subject any further here either. Still further significance of the loss of water by the skin, as Willis points out, may lie in the thickening of the arterial blood. This diminished amount of water of the blood must certainly be of influence upon the processes of diffusion in the tissues; an angiopetal current might be inferred from it, and the undeniable absorption-promoting properties of profuse sweating are thus to be explained. Although this has not been sufficiently investigated as yet, it is still certain that the task of carrying off manifold excrementitious products from the body falls to the lot of the sweat. The excretion of water by the skin probably supports the function of the kidneys and exhalation by the lungs.

It did not escape the older physicians that a sort of antagonism seems to exist between these functions. Röhrig explains the connection in the following manner:—

The delayed respiration and the heightened muscular activity cause an accumulation of carbonic acid in the blood, and this again excites the heart to increased activity, thereby also increasing the formation of sweat. The inverse condition, in which respiration takes the place of the non-sufficient skin function, we observe in animals under entirely physiological circumstances. Dogs, for instance, which possess no sweat glands, seek to make up for the deficiency by increasing the frequency of their breathing and excreting more water by the lungs. Yet clearer is the antagonism between the functions of the skin and of the kidneys. Persons who perspire freely show a decrease in the amount of urinary secretion, and inversely in retention of urine sweating often occurs, which carries off many of the excrementitious materials of the body usually voided in the urine.

Röhrig further points out that the function of the skin also stands in a certain antagonistic relation to intestinal activity, increased perspiration causing constipation, and in-

versely, in cases of inactivity of the skin watery evacuations often occur. The oft-repeated observation that constipation frequently occurs at the commencement of a water cure, as well as the further one, that the most varied forms of diarrhœa are cured by an appropriate water cure, support this view.

The greatest value of sweating I believe to have lain, during otherwise normal renal functions, in the transference of the place where the watery excretion took place, and in the alteration of processes of diffusion in certain internal organs caused thereby, but chiefly in the great alteration of the blood distribution induced by the act of sweating. It is however a different matter when the kidney function is disturbed, and in those diseases which are characterised by diminished metabolism. We must then endeavour, by stimulating the diverse collateral channels, to accelerate tissue metabolism in every direction, and in particular to powerfully promote absorption.

The loss of water and salts, especially chloride of sodium, caused by profuse sweating has a perceptible influence on the constitution of the blood and over alterations of nutrition and tissue metabolism. Since the blood keeps its composition intact as much as possible the tissues and intercellular fluid are obliged to give up a part of their watery contents to the blood vessels when there has been a great loss of water through sweating. In this manner active angiopetal currents and processes of resorption are started by the sweat.

According to the investigations of C. Schmidt, the blood must take up a greater amount of albumen by diffusion from the tissue fluids after its loss in salts especially of alkaline chlorides. Schmidt has shown that between the salts of the blood and the albumen of the plasma there exists a constant reciprocal balancing proportion, in that the blood takes up one part of salt for every nine parts of albumen, and *vice versâ*. Hence the blood plasma should be much richer in albumen after profuse sweat secretion. Such an alteration in the composition of the blood—especially the increase of the albumen in it—must operate very thoroughly on the organic processes of gas diffusion, oxygen assumption, and the excretion of carbonic acid ; but it must at the same time influence and accelerate the excretion of nitrogen.

We shall be able to influence the secretion of urine less by external thermal applications than by the internal use of water. External applications will act upon the function of the kidneys only in so far as they control innervation and the circulation, or alter blood pressure and distribution. The experimental basis on which is placed the statement, that by cold applications to the skin we can quantitatively alter the excretion of urine, has been handed down to us by Colomann and Müller. Still, as far as I know, the influence of external thermal applications upon the secretion of urine has not been sufficiently investigated, especially as regards qualitative alterations which the urine undergoes in thermal operations; concerning this question we nowhere find precise answers. The heightening of the pressure in the vascular system induced by cold seems to cause the diuretic action of the low temperature; on the other hand, the usually rapidly disappearing albuminuria which is often observed after very cold baths may find its explanation in the lowering of the blood pressure which must take place during the period of reaction.

Thermal Influences on other Secretions.

If we glance over the literature we may also find many things concerning thermal actions upon other secretions; the secretion of the bile and of the intestine and the peristaltic motion are, for example, said to be successfully and powerfully influenced. In the chapter on the hydriatic methods we shall find opportunity to touch on certain matters belonging here. Of the influence of heat and cold upon the excretion of CO_2 and N we have already taken notice when speaking of the heat-regulating processes.

2. MECHANICAL ACTIONS OF WATER.

Other actions also, which may be designated collectively as the mechanical actions of water, are brought about by the mode and manner of its application—whether fixed or in an unconfined condition—by its aggregate form and the weaker or stronger force with which it comes in contact with the surface of the body.

The effects thus brought about will partly support the thermal influences and strengthen or weaken them, but they partly likewise develop actions of their own.

On the one side, it is the pressure of the mass of water of itself that causes the mechanical actions of water on coming in contact with the surface of the body; on the other, it is the movement, the impetus, and fall of the water which cause it.

But we also combine at pleasure quite independent mechanical procedures with the thermal or let them follow these in the form of friction, kneading, pressing, chopping, fulling, &c.

The pressure which the weight of the water mass exerts upon the body of the bather is no inconsiderable one; to the usual atmospheric pressure the weight of the water is now added.

According to Mauthner the increase of pressure amounts, for a column of water about 2 feet high, to $\frac{1}{16}$ of the atmospheric pressure, or about 2,280 lbs. more than in ordinary air. This result is obtained from the calculation of the increase of the pressure by $\frac{1}{16}$ if we set down the atmospheric pressure per □″ of the surface of the body as equal to 16 lbs. Marteau has calculated the pressure upon the 15 □′ which the body surface of an adult person is estimated at to be 48,000 lbs., whilst man in atmospheric air suffers a pressure of 27,225 Viennese lbs. The pressure is a still greater one for the bather when he stands in a large, deep receiver, since, according to the same author, the pressure of the water upon a plane immersed in it is equal to the pressure of a column of water whose base represents the plane and whose height is the height of the water above the point of gravity of that plane.

Such an increase of the pressure upon the body is however unaccompanied by any particularly prominent phenomena, and would be still less so if the pressure were not one exerted on the outer surface of one side of the body only; hence in submerging the head this pressure is hardly perceived. The pressure of the water manifests itself by the sensation of greater exertion which the muscular movement requires. Prominent is the feeling of constriction in breathing which is called forth by becoming aware of the greater muscular exertion which will be required for enlarging the thorax, on the surface of which now rests also the whole column of water whose weight

has to be overcome. The pressure of the water also becomes noticeable through an escape of intestinal gases.

The further consequences of the increased pressure upon the periphery are to be looked for in the circulatory system. The mechanical expulsion of the blood from the cutaneous vessels, and the higher pressure under which they stand, becomes most apparent when the body has relatively much superficies to its contents—in other words, in lean individuals. The increased pressure on the periphery of the body must be obstructive to the flow of the blood into the most superficial cutaneous vessels, but especially it must render the return current difficult through the very compressible veins, and, like every other obstruction to the blood current, make itself manifest by its action upon the heart, which consists in increasing its force and accelerating the contraction. The pressure of the water would occasion this to a much greater degree if there were not numerous anastomoses between superficial and deep vessels which allow of the escape of the blood. The blood pressure within the internal organs must in any case be somewhat increased in consequence of this obstruction to the current. The more powerful and accelerated cardiac contractions, of which we made mention, under thermal impressions are no doubt occasioned by the influence of the water pressure as well. The contact of volumes of water with the surface of the body by projection, dashing, friction, or motion operates in a different manner. In general it may be said that these mechanical influences, as well as friction, fulling, kneading, and tapping, operate upon the innervation and circulation and the processes of nutrition dependent thereon, in a manner similar to thermal interference, and that they will support the latter in its operations.

The mechanical manipulation of the skin by gentle or more powerful rubbing (friction, effleurage) causes a nervous stimulation which is capable, according to its power and duration, of effecting an elevation, lowering, or even complete loss of the irritability, and temporary paralysis of the affected nervous region. The physiological proofs thereof have been furnished by various investigations. Türk found that gentle rubbing of an anæsthetic part of the skin was capable of oblite-

rating the limits of the anæsthesia; he also showed that by this manipulation moderate degrees of cutaneous anæsthesia could be caused to disappear. Similar observations made by myself are communicated in my 'Hydrotherapie.' Waller, Eulenburg, Rosenthal, myself, and others have shown that it is possible to increase the sensibility of the skin for touch by such mechanical influences, also however to diminish it. At the present day it is a very common practice to anæsthetise hyperæsthetic spots or diseased joints, and to cure many neuralgias by this procedure.

From what has just been advanced we will hardly be surprised to find a still more effectual means whereby to influence sensory or motor disturbances.

It is not necessary to fear that the mechanical manipulations, like the thermal, will not be able to act upon more remote parts of the nervous system also, for they do this by conduction and by reflex. Hence it may be considered quite rational to endeavour to obtain revulsionary and alterative effects from the periphery by means of thermal and mechanical measures.

The influences of mechanical interference upon the vessels and circulation are still more striking and simpler to follow.

The influence of mechanical cutaneous irritants upon the skin, and hence upon the whole circulation, is already manifest by the change in colour of the skin. Every mechanical impression upon the skin leaves its trace behind it. If we traverse the skin rapidly with our finger, only very lightly touching the epidermis, we will be able to follow the track of the finger by the pale, bloodless delineation which lasts for a variable period.

There are individuals in whom these traces last a long time after the stimulation. The pale streaks which follow the course of the finger are called forth by the expulsion of the blood from the irritated vessels; it does not however seem to be merely a mechanical expulsion of the blood from the vessels which we here observe. The latter indeed is recognisable by the fact that the blood, immediately on the cessation of the pressure, rushes from the periphery of the affected part into the emptied vessels again. There rather appears to be often

an active contraction of the affected cutaneous vessels caused by the mechanical irritation of the skin through the mediation of peripheral sensory nerves, and this continues for a longer or shorter period after the cessation of the irritation. Hence it is that such mechanical irritants are also suitable for the examination of the reflex irritability of the vasomotor nerves and the exhaustibility of their innervation. (The significance of Trousseau's 'taches cérébrales' in affections of the central nervous systems is well known.)

But in addition to contractile actions we can also call forth by mechanical stimulation relaxation of the vessels, and thereby, in a manner similar to that described as occurring on thermal stimulation, act upon the conditions of tension in the vascular system, upon the blood distribution, and the heart's action. We have shown that the thermal stimulation alone often calls forth the contemplated action on the peripheral vessel. Simultaneous mechanical stimulation will teach us how to obtain that effect much more rapidly. By this means we will then also succeed in accelerating and enlarging the abstraction of heat, in more rapidly overcoming the heat regulation and calling forth more powerful temperature effects, most particularly, however, in causing a more effectual alteration in the distribution of the blood and heat.

The agitating effect of the douche is particularly noteworthy in regard to its profound action upon the nervous system and the circulation of the blood. The agitation here called forth by the mass of water falling down in either a condensed or divided stream will act not alone upon the surface of the body, but will also develop its beneficial action in deeper parts by a corresponding relaxation of the superficial muscular layer taking place. The rapidly repeated momentary compression and concussion of the formations encountered will develop a nervous stimulation conducted to the central organ with intense rapidity, an energetic primary vascular contraction, and a powerful reactionary determination of blood to those parts.

This agitatory action must be looked upon in the light of a powerful factor for promoting the motion of the fluids and materials, for the alteration of processes of diffusion in the

tissues, and in direct and reflected alterative actions; it is just this factor which in French hydrotherapeutics has received the fullest recognition, yet in Germany has still not attained the proper recognition and widespread application it deserves.

The agitatory action is to be considered a motor to the circulation of the blood, the lymph and the fluids in like manner as is the stroking process.

These powerful interferences operate upon the movements of arterial blood as agents promoting the circulation in the normal direction of the current, since the *vis a tergo* and the normal rhythmical contraction of the vessels, so like the peristaltic action, prevent a retrograde movement of the blood.

The chafing and compressive action of the heavily descending water must have the same effect upon the venous circulation, as the valves prevent a retrograde movement on the part of the contents, and the mechanical compression elevates the pressure under which the column of blood within the vessels stands. That the secretion of lymph itself, however, is accelerated in the direction of the current by chafing has been proved by striking experiments on the part of Ludwig. His experiments on the motors of the lymphs showed that even an increase of pressure in the capillary was followed by an acceleration and increase of lymph formation.

Lymph, however, must also be more freely secreted when, *cæteris paribus*, the pressure in the lymph spaces sinks, for the superfluous driving pressure within the capillaries thereby becomes greater.

Ludwig has demonstrated that the rapidity of the lymph stream pouring from the opened cervical trunk of a dog becomes increased when the soft parts are periodically stroked with the hand. It is, however, quite clear that nothing more occurs on stroking than that the lymph spaces are evacuated, and that therefore the pressure therein is temporarily reduced to a minimum. Hence acceleration of the motions of the fluids in the normal direction of the current and an increased formation of lymph are the effects of the alteration called forth by stroking or compression.

If we now summarise the benefits and *modus operandi* of mechanical impressions in conjunction with hydriatic proce-

dures it will, first of all, strike us that we thereby loosen the most superficial epidermic scales, remove all useless appendages adhering to the cuticle, and the dried and thickened secretion which everywhere blocks up the excretory ducts of the glands. In the next place we improve the skin for the better discharge of its various functions. By the increased rapidity of the interchanges of the current brought about simultaneously we act improvingly upon the vascularity and nutrition of the dermal organ.

Weyrich has directly shown by his investigations that the imperceptible evaporation of water by the skin may be increased up to 50 per cent. by brief, gentle chafing. The influence on innervation and the movements of the blood, especially in the venous system, will help us to understand the importance of mechanical measures in all passive hyperæmiæ and stases, in disturbances of the circulation, blood distribution, and in the heat economy, besides which processes in the tissues themselves, such as diffusion, secretion, and absorption, are influenced by mechanical actions; and herefrom it becomes clear to us how we can fulfil the most varied indications by a combination of thermal with mechanical measures.

3. CHEMICAL ACTIONS OF WATER.

It is not alone by its temperature and its bulk as such that water calls forth alterations within the organism which find therapeutical application. The chemical composition of water also influences the physiological and pathological nutritive processes, as well by its internal as by its external administration. In external application the chemical composition of the medium which comes in contact with the surface of the body will likewise be of influence upon the nature and intensity of the action. The stimulation which the water exercises upon the peripheral sensory nerve endings must also vary according to the chemical constitution of the stimulant. At equal temperatures and under equal mechanical impression the intensity of the electrical contact current will vary with differently constituted fluids, as Scoutetten, Heymann, Krebs, and others have demonstrated. The property of supplying and carrying off heat varies in waters of different composition; the influence of numerous fluids upon the taste organ varies, as shown by Basch, Santlus, Beneke,

and others; and variable is, finally, the influence upon the tissue metabolism induced by reflex, which has been proved by Röhrig and others. Since, however, the *modus operandi* of waters of different chemical constitution will find proper recognition in another part of this book, I shall here confine myself to the intimation given, and turn to a short consideration of the manner in which ordinary water acts when internally administered.

THE INTERNAL ADMINISTRATION OF WATER.—WATER-DRINKING.

The methodical drinking of common water also finds its application to healing purposes, and its mode of action must here receive consideration. There are here likewise thermal, chemical, and bulky actions to be considered, which interfere directly with the economy, and influence temperature as well as the metabolic processes.

On being introduced into the stomach water is actually incorporated; it remains for a long time in contact with the body, and is brought into direct relation with the different parts of the digestive apparatus through the stomach and intestinal canal. By the equalisation of its temperature with that of the body and its reception into the fluids and the blood, its amount, and chemical constitution, water must have a peculiar effect upon the most intimate nutritive processes of the organism. Water will also play a prominent part as a material of imbibition when internally administered, for it fills and saturates all the tissues and tissue spaces, and makes them pervious to substances soluble in water.

In observing the influence of the internal use of water upon the pulse and temperature of the body, Lichtenfels and Fröhlich found that when 0·3 litre of water (about half a pint) at 18° C. (64·3° F.) was drunk rapidly, the pulse fell by about 22 beats in 30 seconds, returning after 12 minutes, however, to its original frequency.

The temperature fell, after 6 minutes, from 37·05° C. (98·8° F.) to 36·95° C. (97·9° F.), remained so until 10 minutes after the drink, and then returned to 37° C. (98·6° F.) When the same quantity of water at 16·3° C. (61·3° F.) was rapidly swallowed, the pulse sank about 16 beats in 22 seconds, and rose to its original frequency after a quarter of an hour.

The temperature of the body was 0·4° C. less 6 minutes after the water had been drunk, to return after a further 7 minutes to its original height.

In my earlier experiments a litre of water was taken in the morning, fasting, at a temperature of 6·7° C. (43° F.) The frequency of the pulse thereupon fell from 72 to 52 beats, the respirations rose by 5, the temperature in the axilla fell from 37·3° C. (99° F.) to 36·5° C. (97·7° F.), and the temperature of the freshly voided urine had sunk by 0·7° C.

Yet all these investigations only yielded an incomplete result; in order, therefore, to obtain a more intimate knowledge of the influence exercised by water introduced into the body by the mouth and rectum over the temperature and heat distribution, I carried out searching experiments in the following manner: The temperatures were previously taken in the axilla, the rectum, and the stomach, then the quantity of water in contemplation was drunk at short intervals or introduced by irrigation into the rectum. The thermometers, previously exactly compared with each other, were now read off at corresponding intervals of time, and the temperatures noted. The measurement of the gastric temperature I accomplish thuswise: A maximum thermometer 4 cm. long is securely fastened to an indiarubber tube and is swallowed, the end with the thermometer advancing, exactly as if for the purpose of pumping or washing out the stomach. I believe I was the first to carry out temperature measurements in the stomach of the living human being. In this way the thermal influence of the internally infused water may be more exactly estimated than it was hitherto possible to do. As the result of my experiments I may state that the gastric temperature is considerably lowered by drinking cold water for any length of time. Even 30 minutes after 500 c.cm. of water had been taken I was able to make out a difference in the stomach between the temperature before the water had been taken and after it of 0·6° C. less. Even three hours later the original temperature had not yet been entirely regained. Most remarkable was the course of the temperature in the rectum at the same time; immediately on drinking the water the warmth of the large intestine sank continuously through 25 minutes, until a reduction of tem-

perature could be ascertained at this point of 1·05° C. After a very cursory elevation a fall of temperature took place also in the axilla, which continued through 1 hour and 15 minutes. After 75 minutes it was still quite possible to observe a reduction of temperature in the axilla of 0·22° C.; the pulse at the same time showed a decrease of ten beats.

In order to test, by controlling experiments, the remarkable relations existing between the stomach and the rectum which forced themselves upon me in these and similar investigations, I introduced cold water into the rectum by clysters. These experiments led to the noteworthy result that, as when in *drinking* cold water the greatest reduction of temperature is found in the rectum next in order to the directly cooled part, so in like manner did the most conspicuous cooling down show itself in the stomach on the introduction of cold water into the rectum. The gastric temperature sank by about 0·9° C. after the cold clyster.

Besides the proof that we are able to influence the body temperature effectually by the internal administration of cold vehicles we also learn from these experiments that we are in a position to control, at pleasure, the temperature even in very deeply situated abdominal organs by the internal administration of cold water and cold clysters. We can now in the very shortest space of time reduce the temperature of the stomach and neighbouring organs by a cold injection into the rectum, as I have only just now pointed out, and, inversely, we can similarly reduce the temperature of the pelvic organs through the stomach. Many varied general and local therapeutical actions which we attain by methodical drinking of water and methodical irrigation are hereby explained. In the described effects it is perhaps not alone the physical refrigeration which makes itself here felt, but there must be vasomotor influences as well, and numerous reasons speak in favour of this; the alteration of the condition of the skin, for example, its paleness and the fall in temperature of the periphery after the introduction of the cold water, the decrease in the frequency of the pulse, which is perhaps caused by stimulation of the pneumogastric filaments in the stomach—all these speak in favour of this view. I have, however, years ago demonstrated that there is also a reflex

transference of the cold stimulation from the stomach and the intestine to the vasomotor centre by pulse curves which I took both before and after the ingestion of cold and warm fluids.

Only by adopting this theory will the results which we obtain by such manipulations in hyperæmic and inflammatory diseases of the parenchymatous pelvic organs become easier of comprehension.

The roads by which the water introduced into the stomach is carried off are the lymphatics and the veins, as demonstrated for us by Bouisson, who found in dogs after the ingestion of water a very distended portal vein containing blood very rich in water. Various circumstances are of influence on the rapidity of water absorption. The lower the degree of tension in the vascular system the more rapidly will, under otherwise equal conditions, the imbibition of water by the blood vessels take place.

After severe losses of fluids—diarrhœa, hæmorrhages, profuse sweating, and copious discharges of urine; in short, on any impoverishment of the body in water—a more rapid absorption of water by the intestinal tract will be observed; the water which is less rich in salts will be more easily taken up into the circulation than that which contains more salts. Free alkali heightens the affinity of a fluid considerably, particularly when it is of a faintly acid reaction. Fresh water then, rich in carbonic acid and free of salts, will be most rapidly absorbed, and be peculiarly well adapted for drinking purposes. Waters containing more salts will be much more slowly absorbed, and hence call forth a feeling of pressure and fulness in the stomach when even only small quantities are imbibed. Schultz, Nasse, and others have shown that after copious drinking the blood is by about 5·7 per cent. richer in water than after long thirsting. The rapid taking up of water by the circulation increases the pressure in the vascular system, so that, as Magendie and Falk have proved, dropsical conditions may very easily occur thereby. The circumstance, however, that the blood adheres to its constitution with great tenacity brings it about that, as Böcker has particularly shown, this increased amount of water in the blood only continues for a very short time, hardly more than a quarter of an hour in fact. Already in half an hour after the

imbibition of a large quantity of water, however, the blood is again thicker, more consistent, and poorer in water than even after a 24 hours' abstinence from fluid. The fibrin of the blood is said to behave similarly to the water, and the number of the blood corpuscles in a manner exactly opposite. Böcker has further made the interesting observation that after water-drinking the blood clot contains a lesser number of blood corpuscles unfit for respiration, and not turning red on exposure to air, than prior to the water-drinking.

From what has just been said I have deduced the method according to which we should cause water to be drunk for therapeutical purposes, and have found it to be supported by experience.

I stated in my 'Hydrotherapie' that when we desire to saturate the tissues with fluid, to make the column of blood weightier, elevate the tension in the system of blood vessels, and increase the capillary pressure, we must cause the water to be taken in small quantities, but at short intervals of from, say, 20 to 30 minutes for some length of time. When it is requisite to cause the disappearance of watery transudations by powerfully stimulating the absorptive activity, we will be able to promote this object, no matter how paradoxical it may seem, by the drinking of cold water, in that we cause an increased supply of fluid to alternate with longer intervals of abstention from every beverage. The blood thereby becomes more consistent, less watery, and most suitable for the reception of fluids from the tissues and inducing absorption. The ingestion of a somewhat larger amount of fluid every 6 or 8 hours, and abstention from every description of fluid in the interim, best answer this condition.

More rapid absorption once set a-going does not confine itself merely to transudations of fluids; hence we are in a position not only to bring about benefit in dropsies by methodical water-drinking, but we will also have frequent opportunity of observing the accelerated absorption and elimination of firm exudations and inflammatory products under methodical water-drinking.

Böcker has likewise shown that on the increased administration of water the losses of the body generally became more

considerable ; and if the nutritive supply be not increased or be even limited, the blood must regenerate itself, in order to maintain its normal mixture, not alone from the circulating fluids, but from the substance of the body itself, whereby a greater disintegration and increased retrogressive formation will be induced. The augmentation of the body weight under moderately increased water-drinking and an appropriate supply of nutriment proves, however, that accumulation may likewise become promoted by this means.

When an immoderate amount of water is taken in, the body weight sinks, but rapidly rises again when the amount is limited. The increased imbibition of cold water acts diuretically in a true sense ; the organism relieves itself of the larger quantities of water taken in chiefly by the kidneys.

Simultaneously with the increased discharge of water by the kidneys, however, the solid constituents of the urine will be eliminated in greater quantities, particularly the urea. Metabolism in the nitrogenous formations of the body is therefore materially promoted hereby. The conclusion that oxidation increases and becomes more complete under the same influence may be drawn from the diminution in the amount of the excreted uric acid, and from the diminution and complete disappearance of oxalic acid, which before the increased supply of water was very abundant. Moreover the increased oxidation following increased water-drinking may be proved directly by the increased carbonic acid excretion and assumption of larger amounts of oxygen. Salts likewise and inorganic materials, such as the potassium salts, which chiefly spring from the metabolism of the muscles, the fire-proof salts of the bones, and the phosphates and sulphates of the brain and glandular formations are eliminated in greater quantity. The universal stimulation of retrograde change and acceleration of the tissue metabolism caused by increased methodical drinking of common water is still too little utilised in therapeutics ; that no great quantities of water should be taken during the ingestion of food is justified possibly by a too profound cooling down of the stomach during digestion, and too great dilution of the gastric juice which would be caused thereby. Mosler has found that on the ingestion of larger quantities of water the direct elimination of

solid constituents by the kidneys is less than on the gradual administration of the same quantities. Cold water drinking operates also upon other functions; it seems to stimulate powerfully the peristaltic movements, and thereby to promote the circulation in the vessels of the stomach and intestinal canal, to increase the rapidity of the current in the portal vein, and thence to exert a beneficial influence over the function of the liver and the preparation of the bile. The latter has been demonstrated particularly by Bidder, Schmidt, Nasse, Lehmann, and more recently by Röhrig. It will be our endeavour to utilise therapeutically all the actions of water-drinking just described.

THIRD SECTION.

TECHNOLOGY OF THE WATER CURE.

General.

Hydriatic technology teaches us how to methodically apply water in its various aggregate forms and temperatures to prophylactic and therapeutical purposes.

The improvement and development of method substantially promote progress in every department. We have to thank technically more complete and physically improved methods for the greater part of the attainments of modern times in physiology and pathology. Therapeutics also endeavours to improve and complete its methods. Exact methodical operations alone can produce comparable effects; procedures which are not accurately precisioned according to manner and form will not produce comparable effects. 'They are equations with nothing but unknown factors. The disturbance of nutrition is quite undeterminable and variable, changing with the time, the individual, and the form of disease. If the measure now be also not exactly defined the result will be of no value either to experience or doctrine. In this way a rude empiricism will ultimately be reached, but not a sifted, useful experience. A strict method is especially indispensable in physical therapeutics; the perfection of such an one alone will admit of our estimating rightly the value and extent thereof. Therapeutics can be elevated to the rank of a science only through the instrumentality of strict method.' This view concerning the value of method to therapeutics I advanced already in the year 1871, and I adhere to it just as firmly to-day. In

spite of this, the undeniable truth that water, like every other curative agent, brings about much more beneficial actions when methodically applied—actions which differ according to the various modes of application, and which when utilised properly will develop different favourable effects—than when administered without method, has not succeeded in obtaining universal recognition. I go still further, however, and believe I have not asserted too much when I state that actions caused by the unmethodical use of water are entirely due to accident and, *ab initio*, are not even approximately definable. The mode of exhibition of even the most indifferent amongst the bodies used in medicine is well known to every physician. It is not alone the 'heroes' of our medical treasury but the indifferent substances, the whole series of drugs which are there given 'solatii gratia,' 'ut aliquid habeat æger,' that are applied methodically according to certain forms and formulæ.

At the present time, however, it is only the minority of physicians who have even the faintest conception of the various modes of the methodical application of water, based upon its thermal, mechanical, and chemical actions.

The chief reason that the doctrine of water cure has only slowly, and hitherto only outside the pale of the schools, been able to develop itself lies in this, that physicians and clinical teachers never tried to take into account any of these factors, and that it was thought, and at present is partly still thought or rather believed, that to practise hydrotherapeutics a knowledge of the method is quite superfluous. That in this respect better recognition has gained the supremacy the circumstance that it has been given to me to treat of the hydrotherapeutical method in this work is the most eloquent proof.

THE METHOD OF HYDROPATHY.

Be the actions of thermal and mechanical influences upon the healthy or diseased organism ever so well known to us, this does not suffice to enable us in a given case to select the appropriate procedure, and to carry it out in a proper manner. It is rather necessary for this purpose that we should make ourselves more intimately acquainted with the technique of hydropathy, with

the mode of application and execution of the individual procedures generally.

The technique of applying water to dietetic and therapeutical purposes consists—

(*a*) In forms of its external application.

(*b*) In its internal use.

The external forms of application of water are divided, according as they affect either the whole or only a part of the surface of the body, into General and Local.

General Forms of Application of Water.

Quite apart from the temperature we divide the forms of general baths, firstly, into those in which the surface of the body comes into direct contact with the water, without the intervention of any other medium. Belonging to this class we have—

The baths in the tub or in large water reservoirs, e.g. the half-baths and whole baths; finally, the various forms of shower baths, spray baths, affusion, waterfall baths, and douches.

To the category, secondly, of general applications of water, in which the water comes in contact with the body through the intervention of another medium, it being distributed in a thin layer of linen, belong—

Ablutions and friction with the damp cloth, in addition to their subdivisions of cloak shampooing and sheet baths, and wet packing.

To local forms of water applications belong—

The various forms of partial baths, the numerous varieties of bandages, and lastly the different cooling apparata.

I mention the following so as to enumerate the most important forms of partial baths: the occipital, elbow, hand, sitz, and foot baths.

Of the varieties of bandages—head, neck, and chest compresses, trunk, belly, hæmorrhoidal, arm, and leg bandages.

Of the refrigerating apparata—the cooling cap, the cravat for running water, cooling pillows and tubing; Chapman's ice bags, the psychrophore or cooling sound, Atzperger's rectum cooler, the cooling bladder, Kemperdick's intestinal sound, the various vaginal coolers, &c.

To internal water administration belong—

Methodical water-drinking, injection thereof into different cavities, the nasal, aural, vesical, urethral, and vaginal douches, rectal and subcutaneous water injections.

Finally, procedures to excite sweating, dry packing, and steam box baths must be considered.

We shall now proceed to the discussion and description of the technique of these various forms of baths and their *modus operandi.*

THE SO-CALLED TEMPERED OR HALF-BATH.

Method.—An ordinary bedroom bath with not very high sides is so far filled with water of the required temperature that the height of the water column amounts to 6 or 8 inches. Since the bath is only half filled in this form of application, it was called by Priessnitz the half-bath, which is certainly not a suitable designation, the most important criterion lying in the fact that the whole body comes in contact with the water in the half-bath, and not only the half of it.

The small amount of water in the bathing tub for the half-bath is not without its significance in this mode of procedure. It is, namely, not a very easy matter to manipulate mechanically a deeply immersed body freely and properly in the water, and to chafe or pour water upon it as effectively as it can be done in the half-bath. On account of the very short water column resting on the surface of the body the water pressure is also much smaller, and this circumstance is likewise of a certain influence upon the effects of the bath, since under lighter pressure the dilatation of the cutaneous vessels succeeds more easily. The manipulation usual in such a bath is the following:—

After being fortified against retrostasial congestion by cold applications to the head, moistening the chest, eyes, and face, the bathing person steps into the tub, or, if his powers do not reach so far, is placed therein, and is then immediately drenched with the water of the bath by the attendant standing behind him, so that the whole of the body is wetted as quickly as possible. Whilst pouring the water continuously over the nape of the neck and the back, or even over the head if necessary, the attendant keeps chafing the shoulders and back

of the patient with his open disengaged hand. Usually the patient is urged to chafe and continuously to lave with the water the lower extremities and front of his own body, and if he is unable to do this himself another attendant must undertake it. After some time, 2, 3, or 5 minutes, according to the contemplated duration of the bath, the bather can take up the dorsal position; in cases in which the upright position is dangerous (anæmia) he must at once take up the dorsal position.

Meanwhile the attendant saturates the front of the body, and now chafes or kneads the whole of it very energetically under water. The patient then sits up again; the saturation and chafing of head, neck, and back are renewedly undertaken.

This cycle is now repeated several times until the conclusion of the bath.

Modus operandi.—Since the time of Priessnitz half-baths have been applied in acute and chronic diseases, and for dietetic purposes, in such wise that the primary temperature of the bathing water was usually lowered during the progress of the procedure by the gradual or continuous addition of cold water.

Nearly every half-bath then is almost a similar procedure to Von Ziemssen's form of bath, in so far that it is a gradually cooled down bath.

The temperatures of the water used in half-baths are very different, according to the objects in contemplation, and individuality and the condition of the disease have also to be considered in their selection. Degrees of heat of from 23° down to 12° and 10° are made use of for the half-bath (73·4° to 53·6° and 50° F.) Here also we can graduate the thermal as well as the mechanical stimulation at will, and combine each of these factors with the other in various ways and degrees of power.

Very different (and this is *à priori* comprehensible) will be the impression produced by each bath, and also the mode of its action when either the water is left unagitated, the skin of the patient in the bath is not chafed, or water is poured over him or allowed to fall down from more or less of a height, and when the water in the bath is simply agitated. The degree of

nervous stimulation, the magnitude of the heat abstraction, promptitude of reaction, and reactionary elevation or reduction of heat production, as well as the influence on the respiration, circulation, behaviour of the organic muscles, and peristaltic action of the intestines—these, for example, depend entirely upon the manipulations and conduct in the bath and on its temperature and duration. Most value is to be attached to the half-bath as a procedure for reducing temperature. The absolute degree of refrigeration stands, under otherwise equal circumstances, in direct proportion to the temperature and duration of the bath. Influence may also be obtained over the duration of the effects of the bath, in that we endeavour to bring the mode of application into harmony with the laws of reaction, for it is well known that the rewarming after heat abstraction, under otherwise equal conditions, is dependent upon the greater or less rapidity of the reduction of temperature. We can obtain, therefore, a more gradual setting in of reaction and more permanent reduction of temperature after half-baths of high temperature and long in duration than after shorter and colder ones. The urgency of the indication for the instantaneous delivery of a more powerful nervous stimulation, as, e.g., in febrile processes, can alone justify us in selecting low-tempered half-baths, combined with more powerful mechanical stimulation, even in those cases where the process in question must give the indication for half-baths of longer duration.

Indications.—I count the properly utilised half-bath as amongst the most effective and modifiable procedures, and under certain circumstances as scarcely to be replaced by any other.

As a dietetic measure in great irritability of the skin short half-baths are to be preferred to friction, which can sometimes not be well borne and might increase the general nervousness to a high degree. The choice of the temperature is regulated according to general principles; for oft-repeated reasons, low temperatures, 16° to 18° C. (60·8° to 64·4° F.), and short periods are mostly selected for anæmic individuals. In some such cases even only transitory immersions in the half-bath must be the limit of interference, and still good results may often be recorded.

Half-baths of higher temperature, 18° to 28° C. (64·4° to 82·4° F.), and of 6, 8, and 10 minutes' duration, together with affusion, and either with or without powerful chafing, will seldom be adopted in affections of the central nervous system, particularly those of the spinal cord, without marked benefit resulting therefrom.

Pouring water actively over the abdomen in a half-bath of low temperature is a powerful stimulant to the peristaltic action, and will often overcome obstinate atony of the intestinal muscles or obstinate constipation. This system acts equally well in the so-called plethora abdominis, in chronic hyperæmia of the liver, and infiltration of the uterus. Half-baths find their most frequent application, however, in the reduction of temperature in febrile diseases.

I shall have opportunity in a later chapter of showing that the effects and magnitude of the action frequently depend upon the temperature, repetition of the bath and of the mechanical operations combined therewith, upon the behaviour of the bathing person himself, on the duration of each single bath, on the stage and period of the fever, and lastly on the time of day. When the nervous system is seriously implicated, in disturbances of the sensorium, in comatose and soporific conditions, it is often useful to combine the heat-depriving action of the half-bath with the nerve-agitating effect of a waterfall bath, of pouring and dashing colder water over the head and upper half of the body from different heights and with different degrees of force and duration. Well known and approved on various sides are the actions of the so-called waterfall bath on the head, neck, and back of the patient who sits in a half-bath of a higher temperature, in numerous meningeal and cerebral processes. French and German authors have reported a great number of beneficial results in epidemic and sporadic meningitis from the use of waterfall baths and affusion. The half-bath is contra-indicated really only in cases in which any great heat abstraction must be avoided. Such are : far advanced conditions of prostration and collapse, when there is no hyperpyrexia to indicate the urgent necessity for this form of bath, the stage of rigor of all fevers, and all those cases in which the motion necessarily combined with the half-bath, e.g. the transport to

the tub, is connected with peril to the patient, therefore every form of hæmorrhage (e.g. intestinal and pulmonary hæmorrhages).

The Cold Whole Bath.

Method.—This procedure, in order to produce the effect anticipated, must be undertaken in roomy tubs or basins specially fitted up for this purpose with a continuous supply and discharge of fresh water. In private houses the opportunity for using this form of bath will seldom present itself; its application will therefore, most likely, be limited chiefly to hospitals and institutions which are specially fitted up for carrying it out.

The temperature of the water to be applied as a whole bath must be the very lowest which is at all at our disposition, and through the continual discharge and supply of water it is to be kept at the same point continuously. Higher temperatures than 10° to 12° C. (50° to 53·6° F.) and lower ones than 6° C. (42·8° F.) could hardly find application here; seldom will anyone order a whole bath without previously preparing the body for this powerful procedure.

Hence it is chiefly to be prescribed following wet or dry packing or vapour box baths; in a word, only when the temperature has been artificially elevated or when large quantities of heat have been massed on the surface of the body, and the cutaneous circulation has been greatly accelerated.

The patient thus prepared is plunged and immersed rapidly either immediately in the whole bath, or he first steps into a tempered half-bath at 16° to 20° C. (60·8° to 68° F.) for 1 to 2 minutes, and then enters the whole bath for from $\frac{1}{2}$ to 1 minute, to return again to the half-bath in case the refrigeration is to be a very considerable one, when too intense a reaction must be prevented.

Returning from his whole bath of 8° to the half-bath at 16° to 14°, the patient experiences a sensation as if he were in a lukewarm bath. Applied in this manner the whole bath belongs to the most agreeable procedures of hydriatic technique.

In the whole bath the patient must make as much muscular movement as he is able, and dip his head under the water once or oftener.

Modus operandi.—Phenomena of nervous stimulation, of heat abstraction, and of one other influence to which we have hitherto had no opportunity of referring at length—namely,

the water pressure—here become markedly manifest. The very low temperature of the water in the whole bath, the simultaneous wetting of the whole surface of the body by it, and the antecedent warming of the body are the causes of the great nervous stimulation in this procedure.

Rapid hyperirritation of the cutaneous vessels, the accelerated circulation in the skin in consequence of the antecedent accumulation or supply of heat, and the low temperature of the water increase the sudden heat loss to a very great extent. The water pressure itself comes into operation by rendering the muscular action of the bather difficult, and thereby communicating to it the effect of oppositional movements.

During the bath even, or shortly after leaving it, the skin loses the paleness or cyanotic colouring which may often be observed on entering the whole bath, and rapidly becomes of an equal, intensely purple reddish colour; the coldness of the water is not any longer unpleasantly felt, and a feeling of comfort steals over the patient. The stiffness and immobility of the muscles which made itself felt at the moment of immersion disappears, the feeling of constriction is allayed, and the at first impeded respiration becomes free and deep. The after effect of such baths—that is, the reactionary elevation of temperature—is much more intense than in any other form of bath. Often the heat of the body rises a few hours after the bath by a whole degree, hence its powerful action upon the tissue metabolism. The bath must be quitted whilst this condition of complete and lively reaction still holds, for late or so-called 'second rigor' must not be allowed to come on in the bath.

This 'second rigor' manifests itself by a renewed alteration of colour in the skin; the lively, equally distributed purplish red gives place to an areolar, bluish coloration, which ultimately becomes completely cyanotic, the face becomes pale, the lips blue, peripheral parts get a corpse-like appearance from spasm of the vessels of the skin, rigor sets in, and finally tonic spasms, singing in the ears, and fainting fits come on. The reaction after a heat abstraction carried to such an extreme usually comes on late and is incomplete or excessive; febrile disturbances, even inflammatory affections, e.g. inflammation of the lungs and acute nephritis, are said to have been already observed

after it. Not uncommonly evening febrile attacks and great loss of flesh are the consequences of long-continued and repeated excessive heat abstractions such as these. I only once had the opportunity in a water fanatic, after a whole bath of 8° continued to the second rigor, of taking a temperature measurement in the rectum 20 minutes after the bath during still continuing severe rigor. The thermometer showed 35·8° C. (96·4° F.); 4 hours later it showed 38·1° C. (100·6° F.) The man, who had been formerly very strong, as he said was 50 years of age, was said to have been treated by Priessnitz for syphilis, and was now suffering from syphilidophobia; year after year, therefore, he cured every acne pustule which appeared with the most energetic hydriatic procedures on his own account. He was reduced to a skeleton when I saw him, and had an appearance and a condition of the skin such as I have never again beheld. The skin was dry like leather, inelastic, without fat, and bloodless, and gave one the impression of a lifeless tissue. The individual could not be induced, as I advised him, to knock off the water-cure, and quitted me indignant at my felony to the original Gräfenberg traditions.

Less prominent but still plainly recognisable seemed to me this peculiar paralytic condition of the skin in children who had been exposed to an unsuitable cold *régime* by their relations who suffered from water fanaticism. The peculiar condition of the skin, aged appearance, the loss of flesh, and disturbed nutrition—in a word, *the phthisical phenomena*—in conjunction with the condition of the skin aforementioned are so characteristic that whoever has seen such a condition once will thereafter ever recognise it at the first glance. The so-called 'hydropathists' adorned these results of their errors with the euphonical phrase, 'satiety by the water cure.'

The effect of this very effectual form of bath, i.e. the whole bath, is therefore a powerful stimulation and elevation of the organic functions on all sides and a lively acceleration of the tissue metabolism.

Indications and contra-indications for this procedure are established therefrom of themselves.

The whole bath is prohibited, in the first place, in all far advanced conditions of prostration and in high degrees of anæmia, in either of which cases quite transitory immersions

even have been observed to act beneficially instead; then in high-graded disturbances of nutrition, extensive loss of flesh, depascent diseases, phthisis, lung and heart affections (on account of the primary retrostasis), also in congestive tendencies, diseases of the vessels—atheromatous processes—and all febrile disorders; it is likewise contra-indicated in most diseases of the nervous system.

The whole bath is indicated, and often to be replaced by no other procedure in a like effectual manner, in nutritive disturbances displaying the character of torpidity, torpid scrofulosis, obesity, and in dyscrasic processes, e.g. syphilis—in a word, wherever the metabolism requires to be powerfully stimulated and a retrogressive metamorphosis to be instituted.

THE SHOWER BATHS OR DOUCHES.

General and local douches are to be distinguished. To the general are reckoned the shower, the jet douche, bell douche, circular and spray douche, and the movable jet and fan douches.

Method.—Under the term shower bath we understand that appliance in which the water descends through the rose of a watering can in single streams, which are finer or thicker according to the calibre of the openings of the rose, from a height of about 3 metres above the ground. The conducting pipe is fitted with a valve or a cock to stop the supply, and in well-furnished institutions where shower baths are applied to therapeutical purposes this stopcock is so placed that it cannot be handled by the bathing person but only by the physician or an attendant. In this way alone is it possible to regulate the manner of application of the douche according to duration, force, and temperature, so that it exactly suits the given indications.

When the conducting water pipe ends in a simple circular metal point, like the nozzle of a fire pump somewhat, $\frac{1}{2}$ to 1 cm. broad, and pointing downwards, this forms what is called the jet douche. Here it is the undivided jet of water which strikes the patient, and which he allows to play either directly or indirectly upon the various parts of the body according to the indications.

When the water pressure is very high and the openings in the rose are very small, the water which rushes out upon the opening of the valve is literally atomised, and the patient standing beneath such an appliance is enveloped in a dense mist of spray. Such a douche is termed the spray shower bath. A variety of other forms of the

douche may be distinguished according to the shape of the discharge opening, such as bell douches, annular and capeline douches.

The movable douche (*douche mobile* of the French) finds the most frequent application to therapeutical purposes, and is the most capable of modification in its appliance.

We distinguish as the movable jet douche that from which a more or less condensed jet of water escapes from a simply bored metal point on opening the tap; by means of various accessory mouthpieces this stream may be converted into the movable horizontal shower douche or the movable fan douche.

By means of this appliance, as we shall soon see, we are able to fulfil the most manifold indications. In order, however, to do complete justice to these indications there must also be an appliance whereby water of any required temperature can be conducted with a variable and voluntarily alterable pressure power to the mouthpieces of the shower baths. By this means it will then be possible to allow warm and hot as well as cold water to operate upon the patient rapidly one after the other through the same mouthpieces. This alternating hot and cold douche has been designated the Scotch douche.

Movable vapour douches are also often usefully combined with the cold horizontal jet or fan douche.

According to the regions of the body which the movable horizontal douche plays upon, the French differentiate: the liver douche, spleen douche, epigastric, hypogastric, vaginal, uterine, perinæal, and hæmorrhoidal douches; and these again, according to the direction of their outlet, are called either ascending or descending douches.

Modus operandi.—The operative factors here are also thermal and mechanical. The peculiarity of the shower baths consists in the water remaining in contact with the body only during the moment of incidence, flowing down from it immediately after, and in the very peculiar mechanical action which can be graduated at will and localised to any part of the body. Every drop of water falling on the body will therefore renew the thermal stimulation in the highest degree, but will only deprive the part of a small amount of heat on account of its cursory contact, since it is impossible for it to place itself in complete thermal equipoise with the smitten part within the short space of time allotted. The constant renewal of the contact

by a continuous fresh supply of watery particles will increase the total heat abstraction to a much greater degree, equal duration with other procedures being given, and the nervous stimulation also will be in general a more considerable one.

The specificity of the action of the douche lies in the peculiar mechanical impression, the continuous concussion, and the shock and descent of the watery masses. The power and effect of these factors are dependent—

1. Upon the pressure under which the water within the conducting pipe stands; in the ordinary appliances therefore, upon the height of the column of water.

2. Upon the nature of the outlet, that is therefore upon the condensed or separated character of the outflowing water.

3. Upon the duration of the operation.

4. Upon the temperature of the water used.

Temperature, the duration of application and mechanical influence however, do not in any way satisfactorily and rationally explain the mode of action of this powerful measure. The physiological phenomena perceptible by the senses are also worthy of attention.

The influence of the douche upon innervation may be computed from various facts; the skin becomes hyperæsthetic after a very short period of application. At smaller distances apart the æsthesiometer's points are still felt as distinct shortly after the douche, whereas they previously created only a simple impression. Temperature sense seems also to become more delicate. Long-continued douches are capable of leading to a diminution of cutaneous sensibility in every one of its qualities. The influence also of this procedure upon motor tracks is undeniable. The feeling of power may thereafter be an elevated one, and the electromotor excitability be heightened. Muscles, too, deprived of their voluntary power by disease, or such as only incompletely obey volition, we observe to become accessible in a higher degree to nervous influences during and after the use of the douche. Reflex excitability is usually increased. Rarely, and indeed only on continuing the action of the douche, particularly of the local, to an extreme degree, can the excitability of sensory, motor, and vasomotor nerves possibly be lowered or destroyed either temporarily or permanently.

The latter effect will also find therapeutical utilisation in the local alternating so-called Scotch douches, whose efficacy consists in the alternating action of cold and hot baths, or vapour baths, when applied to the treatment of neuralgias, pathologically increased excitability of striped and smooth muscular tissue, and similar diseases of the intestines. As an actual heat-depriving process the shower bath is seldom used. It is principally applied to the treatment of nervous diseases, diseases in which we wish to obtain a controlling influence over the circulation and distribution of the blood and cases in which it is our endeavour to place certain groups of muscles of active or passive nature in a condition of increased tonus, or to stimulate them even to tetanic contractions. Disturbances of nutrition and of the blood elaboration, anæmia, dyscrasias, malaria, hypertrophy of parenchymatous organs, and nervous affections are accessible to this procedure, which forms a very powerful hydrotherapeutical factor. Against old chronic exudations also and inflammatory processes which display no sign of becoming absorbed, the local forms of the douche particularly are often applied with benefit. Here the mechanical stimulus, which effectively alters the nutritive processes, is the profound and energetic concussionary action. In general it may be said that we possess in the various forms of the shower bath a powerful nervine tonic, revulsive, alterative, absorbent, and derivative agent. Against no other hydriatic procedure does there exist so deep-rooted a prejudice as against the douche. It is only exceptionally that a patient who has been sent by his physician to a hydropathic establishment does not carry instructions to be sure not to make use of the douche, and in particular he is warned against the head douches. The hydrotherapeutists must be generally taken to be very deficient in doctrines of their own if by such instructions the warned one is supposed to have received any service.

It is not difficult to understand how the prejudice that douches have such a deleterious effect originated.

Apparently it belongs to experiences and traditions which may be traced back to the days of brutal hydrotherapeutical empiricism. It was the practice, namely, to place nearly every patient at least once daily under a shower bath in the forest.

At Gräfenberg, e.g., this douche consisted in a perfect little torrent which rushed down a wooden gutter and terminated in a thick waterfall several metres above the ground ; for from 5 to 10 minutes, and even longer, many patients exposed themselves to this stream in all kinds of weather in the open air. Is it any marvel then, that it would happen that many a patient underwent a change for the worse in his condition, or even acquired fresh diseases? These evil results coming to the knowledge of the physicians seem to have given rise to the bad opinion which is even to-day, at least in Germany, here and there maintained regarding the douche. Whoever will now compare such a procedure with the application and action of a shower or of a movable fan which is applied by the practised hand of the physician or under his directions, with known and graduated force, duration, and temperature, must confess that these two procedures have nothing in common. If we turn our gaze upon France we shall quickly perceive that there this prejudice was long ago broken and banished. The various forms of the douche are nearly the alpha and omega of French hydrotherapeutics, and we see them there applied, modified rationally, with the greatest benefit by the most prominent clinicians. The modifiability of this procedure according to time, temperature, force of impact, and localisation allows of the most manifold indications being fulfilled therewith, and thus the range of action of the douche embraces almost the whole region of hydrotherapeutical operation: nerve stimulation of different strength, heat abstraction (gradual and under our complete control), vascular contraction and dilatation, alteration of the blood distribution, influence over the heart's action, the respiration, &c.—may all be attained by the aid of this procedure, similarly as with the shampooings, only in a still more decided manner. The French, following the example of Fleury, divide the douches, according to their *modus operandi*, into stimulating, soothing, alterative, and strengthening, &c. We shall presently demonstrate that it is not the procedure but the individual affected that reacts so variously upon the stimulation, varying according to intensity, duration, and application.

A local, very peculiar form of application of the water jet is the so-called 'douche filiforme,' the hydriatic moxa or needle douche.

The Douche Filiforme of Lauré.

Description.—The douche filiforme consists of a water reservoir (A) within which a suction and force pump (B) is secured. The sucker of this pump is set in motion by a long lever (C).

The pump forces the water into a flexible yet inelastic metal tube (D) which is brought into watertight connection with the outlet of the pump chamber by a covered screw joint. This metal tube carries a metal capsule (E) at its free end which can be unscrewed, and into the centre of which a conical

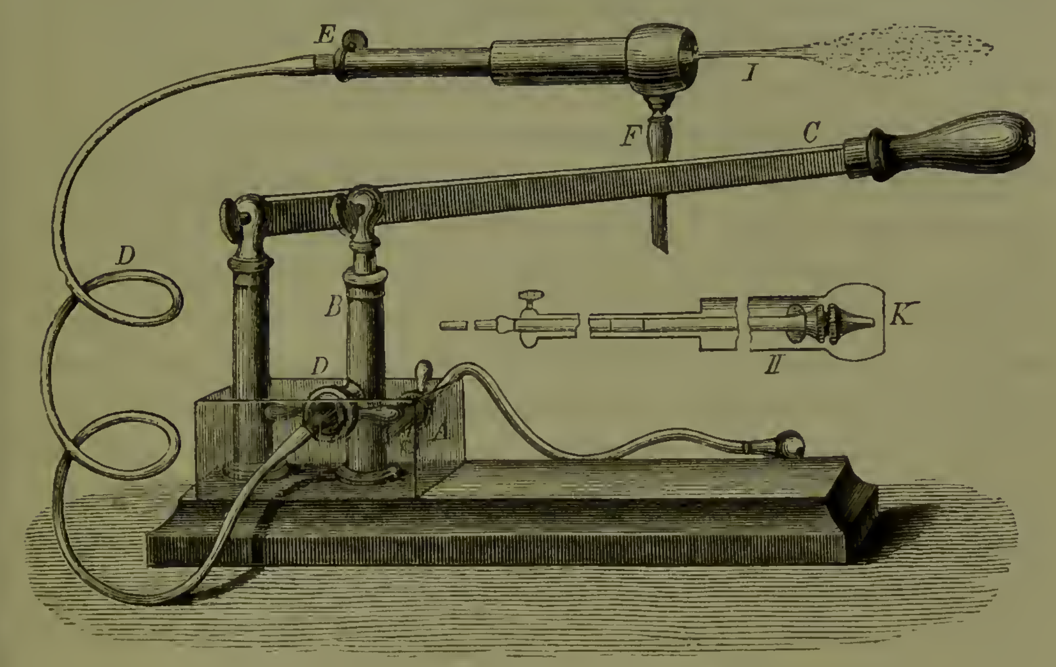


Fig. 42.—Douche filiforme. (After Lauré.)

perforated ruby or rock crystal is fitted. The pump forces the water through the stone in the condition of a very compact jet of water fine as a hair, which only breaks up at some distance further into a cloud of watery vapour.

According now as either the compact or the atomised jet is directed against a part of the body there may be produced either merely a slight redness or actual blistering, as the case may be.

Modus operandi.—According to this then, the filiform douche acts like any other rubefacient or epispastic, e.g. mustard leaves or oil of mustard, vesicating fluids and pastes. The large filiform douche constructed by Matthieu consists of a very powerful force pump which is put in motion by a long lever handle, and possesses a great number of small holes in a

column; a similar number of needle-like jets thus act upon the skin of the part of the body exposed to their influence. This appliance is chiefly used along the spinal column, especially in the various forms of spinal disease, and spinal irritation more particularly. To the category of general water applications belongs

The Ablution.

Method of operating.—Ablution is performed either by the hands of the attendant, which are dipped into the water, or by means of a sponge or damp towel. The patient may remain in bed during the ablution or sit upon a chair; every part of the body is then singly bared, washed, dried, and again covered.

In the ablution we have the means of cooling more or less each part of the body and stimulating it mechanically with more or less energy. If the ablution is to involve the whole body a distinct order of progression must be observed. The hands and forearms are begun with; then the face, head, neck, and chest are taken; the nape of the neck, axillæ, arms, back, abdomen, and gluteal region follow next in order; and the thighs, legs, and feet bring up the rear. Ablution must take place very rapidly and cursorily, and is best done in such a manner that every part is enveloped by itself in a towel which has been previously wrung out in the water at the required temperature, and then vigorously chafed through the towel, not with it. In this way the ablution is converted into a partial chafing. Immediately the wet cloth has been removed the washed part must be either rolled in a dry cloth or enveloped in a second damp one and renewedly chafed as before, this having to be repeated until the desired effect is brought about. At the conclusion of the procedure the drying process and, as required, more or less vigorous chafing must always take place.

It is necessary in carrying out ablution to have several vessels at hand containing the water tempered according to pleasure and requirement, so as to be able to rinse and cool the used towel in a different vessel from that in which it is wrung out before application, when it will have the required temperature of the water last used.

As regards the temperature of the water used in ablution, this may always be colder than that which is used in pro-

cedures in which the whole surface of the body simultaneously comes in contact with the medium of lower temperature. As we have shown, the nervous stimulation grows in direct proportion to the number of sensory nervous end organs which are involved at one and the same time; furthermore we will select the lower temperatures of water for the reason that our principal object in carrying out this procedure is to obtain dilatation of the peripheral vessels. Hence such ablutions are usually undertaken with water at 8° to 12° C. (46·4 to 53·6° F.)

Modus operandi.—Ablution is one of those procedures which enlighten us concerning the conditions of irritability of the vascular nerves. When, after ablution and chafing, the skin of a part remains pale instead of becoming rapidly red, and grows very cold, to restore its heat quickly by means of drying and friction being apparently impossible—this will give us the general characters of the disease and be a criterion for our future treatment.

In chronic diseases it is a sign of great irritability of the vascular nerves when, during ablution, the skin only very slowly reddens or remains quite pale. In acute diseases this behaviour gives us information regarding existing heat retention, and is frequently a sign of high-graded anæmia.

When under ablution the skin becomes lividly red, and an areolar injection skin follows, there must usually exist an incomplete *vis a tergo*, which again points to weakness of the heart and threatening collapse. It is likewise a sign of impending collapse when after the ablution in febrile diseases the surface of the body only slowly rewarms itself, or if the previously very high temperature is deeply reduced by only a passive ablution.

Often indeed it is possible by merely a passive ablution of the forearm alone to timely foretell the approach of a collapse scarcely as yet indicated.

Indications.—The ablution is only made use of as a mild nerve stimulant to prepare the body for giving off a greater amount of heat and to set free retained heat. The action of the ablution is only a very slight one, and we can hardly attain any appreciable reduction of temperature by it. If therefore we require to bring about greater positive bathing effects, we will previously apply the ablution so as to make the skin, to a

certain extent, more suitable for greater heat discharge and to prepare it for that task.

From the investigations of Leyden,[1] Botkin,[2] and others, it is very likely that in fever a retention of water within the organism takes place, and Weyrich [3] has proved decidedly that even by slight friction of the skin the evaporation of water from it will be often increased by more than 50 per cent.

Hence we will apply the ablution, on account of its mechanical action, *to increase the evaporation from the skin and remove the retention of water* in fever and other patients, or at least to diminish it, and thereby contribute towards the easier removal of the disturbance. On this action, namely the restoration of the perspiratory activity of the skin, rests the result that the skin, which was previously dry and brittle and in fever patients burning hot, feels moist, soft, and fresh after the washing and drying process. *On these grounds, therefore, I am fond of recommending ablution as the first procedure in fever cases*; [4] also, however, for the reason that the mild thermal nervous stimulation awakens a passive feeling of comfort in the patient, strengthens his faith in the method, and gives the best information concerning reaction, state of the bodily strength and of the heart's action, intensity of the fever, and condition and behaviour of the nervous system during its progress.

Shampooing.

Method of Procedure.—The process is as follows: Into water, which is more or less cold as the indications require, is dipped a sheet, which is then wrung out more or less and wrapped around the body in the following manner: The bath attendant holds the sheet for this purpose, which must be 2·5 metres long and 2 metres square for an adult, in such a manner that he has in his left hand the superior edge of the sheet; the part which he is unable to keep stretched between his outspread arms having been folded he now steps before the naked patient or beside his bed with the sheet thus spread

[1] *Deutsch. Arch. f. klin. Med.*, 'Ueber das Fieber im Allgemeinen.'

[2] *Medic. Klinik in Demonstrationen, Vorträgen*, part ii. Berlin, 1869.

[3] *Die unmerkliche Wasserverdunstung der menschlichen Haut.* Leipzig, 1863.

[4] The procedure here described is certainly not the same as is described in a few medical works as being useful in fevers, and is there spoken of as 'sponging;' the ablution may be accomplished by means of a sponge (as the vehicle for the water), but it nevertheless remains an ablution or washing, the only English equivalent we possess for the original word.—Translator.

out and freely depending. The person to be shampooed, whose face and head have been cooled in the proper way before wrapping up in the sheet, so as to guard against retrostasial congestion, is now rolled so far as the breadth of the cloth will allow into the sheet $1\frac{1}{2}$ time or twice, a cold wet cap having been previously drawn over the head. It is equivalent to undertake the wrapping up in the wet cloth in such a manner that the one corner of the superior edge being held tightly between the arm and the trunk of the body, the sheet is carried across the thorax to the other axilla, then over the back to the right shoulder, and finally is laid over the shoulder yet free. By the corner which the attendant still holds in his hand the sheet is fastened at the neck, and it is also jammed tightly between the thighs and legs, so that it may lie with as few folds as possible close to the body and be there retained during the operation of shampooing. The bath attendant now draws his flattened and closely applied hands with long and more or less powerful strokes up and down the body of the patient at a very rapid pace.

The attendant has to be careful that every part of the body is shampooed in suitable order of progression and repeatedly take particular care that the sheet be equally warmed in all its parts. It is indicated under some circumstances to replace the chafing by rapidly applying the hands to the sheet and surface of the body; this obtains when friction is not borne in individual portions of the body.

This system of procedure is known as 'slapping;' the latter procedure is often also combined with the former: the sensitive parts only are slapped, the less sensitive are chafed.

If the shampooing or slapping process is to cause a still greater abstraction of heat, water at temperatures varying according to the indications is poured over the patient enveloped in his sheet. The local or general heat abstraction may be increased at pleasure by pouring the water either only on single spots under the sheet which display greater heat or drenching the whole body once or oftener (sheet bath). The amount of heat abstracted may be also graduated by wringing out the sheet more or less powerfully, whereby the amount of water contained therein becomes greater or less as the case may be. A dripping wet cloth will abstract more heat than one wrung out more forcibly; a fine sheet will abstract less heat also than a coarser one. In shampooing with a rough sheet the mechanical

stimulation will be more powerful, temperature of the water and force of the friction being the same, than if performed with a fine linen sheet.

Where an indication exists for a greater heat abstraction with simultaneous powerful mechanical stimulation we will choose a dripping wet, coarse linen sheet; where only powerful stimulation and slight heat abstraction are required, the coarse but well wrung out sheet is most suitable. In very great irritability and hyperæsthesia of the skin the object will be attained by shampooings in fine sheets.

When it is desirable that the bather should exercise his muscles during the procedure—in fact, assist in it—it will be advantageous to apply the so-called 'cloak shampooing,' which is carried out by the attendant throwing the sheet from behind over the shoulders of the patient like a cloak; the patient then seizes the anterior ends of the cloth and rubs therewith the whole anterior half of the body, whilst the bath attendant rubs the back in the same way.

Modus operandi.—It is hardly necessary once again to prove that the sudden envelopment of the whole body in a cold, wet linen cloth exercises a most powerful nervous stimulation upon the peripheral sensory nerve endings. The stimulating action of shampooing will be much more powerful than that of the ablution, since in the former a greater number of sensory nervous end organs are met with than is the case in the ablution. Hence there will be also a more powerful incitement conducted to the central organ, and much more pronounced reflexes set free on motor tracks. At the moment of the impression a contraction of the cutaneous vessels encountered takes place, blood is expelled from the periphery, and a rather considerable retrostasial congestion towards the brain might take place. We must guard against this by elevating the tone of the vessels of the head by means of affusion, wet bandages, wetting the neck, nape, and back, and should we not sufficiently cool down these parts phenomena will appear which point to an increased determination of blood to the head, such as a feeling of heat and headache.

The next symptom due to shampooing is an alteration in the type of the respiration. In very sensitive patients the

respiration is momentarily interrupted by an inspiratory spasm, and soon afterwards accelerated, deeper breathing sets in. In less sensitive individuals the accelerated and deeper breathing sets in at once, and if a pathologically accelerated respiration existed before the shampooing, this will be lessened in frequency after the operation, yet the individual inspirations will be deeper. Yet further, an alteration in the pulse frequency is observed, and this consists in its retardation. Very likely this retardation depends upon a reflex excitation of the medulla oblongata, just as does the altered type of respiration, which is transferred to the origins of the vagi. Indeed, we see even in direct electric stimulation of the vagus or medulla oblongata that the frequency of the pulse is lowered thereby. The slowing of the pulse rate and the acceleration of the respiration are not capable of being numerically well established, according to my experience, since the magnitude of the action is dependent upon too many individual circumstances.

Pleninger found that when the pulse rate was nearly 100 or more prior to shampooing, it sank two minutes after by 20 beats, whilst the frequency of the respirations increased by about five in the minute.

Since the lessened pulse rate and accelerated respiration are attained before even an alteration of the body temperature, in other words, before a greater abstraction of heat could take place, it may be stated with certainty that the abstraction of heat does not cause the primary action in question. The action of the temperature reduction only makes itself felt later on in the same direction. It is clear that this primary effect is one originating by way of reflex from sensory peripheral nerve endings.

There exists a certain constant proportion between the frequency of the pulse and the respirations. Accelerate the respiration whilst the pulse rate is diminished, and a lessened number of beats will fall to each respiration. The cardiac activity will be slowed, the individual cardiac contractions become more free and powerful, whilst with each systole a larger amount of blood is thrown into the great and lesser circulations. Each wave of blood which is driven with the systole into the lungs from the right side of the heart must

there remain some time in contact with the atmospheric air, and since the inspirations increase in frequency and depth when cold acts from the periphery, the excretion of carbonic acid will also become more complete, and thereby the residual air in the lungs will be richer in oxygen and poorer in carbonic acid. The gas exchange between the blood and the pulmonary air will be a more complete one in other words.

The direct consequential phenomena of a powerful wet and cold shampooing, carried to the pitch of cutaneous reddening, are therefore greater oxidation of an equally large amount of blood, more forcible but retarded blood movements, diminished tension in the arterial system, mechanical promotion of the circulation, altered blood distribution, reduction of the amount of blood in the internal organs, and greater vascularity of the skin.

In addition to these, the powerful nervous stimulation combined with shampooing must be taken into account, and we are right in attributing to this procedure a so-called tone-giving effect. Together with the increased retrogressive metamorphosis and more accelerated elemental analysis of organic matter, accumulation will also be promoted, and there is a greater want of nourishment felt. We gather herefrom that it is beneficial to apply shampooing to the treatment of disorders of nutrition and digestion. On account of its derivative action we will also make use of this procedure in hyperæmias, congestions, and stases within the internal organs, in cases where it is desirable to divert the blood from the inner organs and in the most manifold disturbances of the circulation, even in such as are the result of organic diseases of the circulatory apparatus.

This explains the assistance given to the compensation of valvular incompetency by this procedure; hence the beneficial effects attending its application to lung affections where hyperæmia and stasis exist in the lesser circulation, e.g. emphysema, hyperæmia of the lungs, and catarrh; hence also the beneficial effect of this procedure in gastric and intestinal catarrhs and hyperæmia of the parenchymatous abdominal organs.

The powerful nervous stimulation, excited by the sudden

contact of the cold, wet cloth with the skin, may be still further heightened by seeking to elevate the sensibility of the nerves to irritation beforehand. This is accomplished by elevating the temperature of the surface of the body by the accumulation of heat thereon, as the stimulant action is greatest when great contrasts of temperature exist. As the surface of the body is warmest in the morning in bed through the bad heat conductors and the quiet position during the night, and there is therefore likewise heat stored up, we will obtain a more intense action by shampooing the body, cold and moist, direct from the heat of the bed than at any other time.

When, however, as is the rule in the anæmic, a sluggish heat production and irregular heat distribution take place, so that the hands and feet remain always cold—and even in bed in the morning the surface of the body is cold—then shampooing from the bed heat is inapplicable. In such a case heat must first be stored artificially by covering the body liberally with non-conductors (blankets or feather beds); or letting a wet pack, for the duration of half an hour to an hour, remain on the body until the whole surface is equally warmed; or lastly by giving a vapour bath of a few minutes' duration.

Thus the combination of these procedures with shampooing, will, in the gentlest manner, bring out the tonic effects of the latter. The body surface temperature is elevated thereby, the irritability of the peripheral nerve endings is increased, and the shampooing, if undertaken, will now be of more powerful operation. This mode of application is also more gentle on account of the abstraction by the refrigerating process of only the heat stored on the surface, and the carrying off of what was only spare heat. Anæmic and convalescent patients will derive great benefit from shampooing carried out in this manner. Secretion by the skin is also stimulated to increased activity by shampooing. Weyrich has shown that, by the mechanical irritation of the friction alone, the watery secretion by the skin is increased by about 60 per cent. and more. This action of the shampoo would hence be very proper in dropsical affections for obvious reasons; also in all those cases where, together with the disturbance of nutrition

existing, there is combined a retention of water, e.g. in the beginning of febrile diseases.

By means of the thermal and mechanical interference combined in the action of shampooing in a cold, wet sheet, we can obtain well-nigh voluntary influence over the body temperature. We will be in a position first to reduce the rectal temperature and elevate the axillary, and secondly to lower the latter as well—in other words, to actually reduce the body heat. In an experiment which I made on a young man, aged twenty-seven, with cold, wet shampooing the axillary temperature was 37·29° C. (99° F.), the rectal 37·15° C. (98·8° F.), prior to the procedure ; four minutes after it the axilla, which had been directly cooled by the wet sheet, had a temperature of only 35·7° C. (95·6° F.) ; in thirty-five minutes more it had risen by 1·2° C. The rectal temperature was reduced by 0·2° C. after the process, and after twenty minutes more by 0·15° C., at which degree of temperature it remained until a further heat abstraction, the so-called air bath, reduced it still more ; whilst the axillary temperature was forced to rise still further. Immediately after the air bath the temperature had fallen in the rectum by 0·4° C., whilst the axillary temperature only began to rise several minutes later. The difference between the rectal temperature and that of the axilla amounted to 0·15° C. immediately before the air bath, and to 0·55° C. immediately after, whilst thirty-eight minutes after the air bath it stood 0·4° C. to the credit of the axilla.

Further indications for the use of shampooing may be easily deduced from this mode of action of the procedure, from the influences of the heat and water retention, and from the lowering of the body temperature. In the commencement of febrile affections shampooing will be of great service in setting free the accumulated heat, in preparing the body for more powerful heat abstractions, and in the decision as to the resistance of a febrile elevation of temperature.

In children when rashes are imminent one often sees how, immediately after the shampooing, the exanthem, which had previously not been recognisable, has actively come out. Shampooing then will act as a diagnostic aid in many cases by causing the necessary alteration in the condition of the skin.

The heat-abstracting action of the procedure may be heightened by pouring cold water upon the sheet (sheet bath), whereby precisely those parts which display a greater accumulation of heat can be cooled the more. It is further possible to abstract double the amount of heat by applying two sheets one over the other. In some febrile diseases, particularly in their advanced stages and in threatening weakness of the heart, when in certain parts of the body—e.g. the hands and feet—phenomena of heat retention are present, we can convert the irregular heat distribution into a regular one by simply slapping those parts which display an active heat discharge (by more or less powerfully placing upon and raising the flattened hands from the skin), and repeatedly pouring water over them (sheet bath); whilst, on the other hand, those parts which only slowly warm the cloth are powerfully chafed and not drenched with water.

If we allow the damp linen cloth, already warmed by the friction, to remain any longer in contact with the surface of the body the thin layer of water contained within its meshes, which is now warm, will begin to evaporate and thereby deprive the body of still further amounts of heat. A greater reduction of temperature then may be obtained by continuing to pour water over the sheet and lengthening the whole procedure. The discharge of heat may be yet further increased by frequent slapping and more or less powerful chafing, which keep the cutaneous vessels in a condition of dilatation, and the appearance of rigor is delayed.

The delaying of the rigor in heat abstractions is of the utmost material importance to the amount of real temperature reduction, and it is therefore a great object in the thermal treatment of febrile diseases. Existing rigor and the retention of heat ascertained thereby, are likewise suspended by shampooing. As is well known, rigor sets in when there is a great difference between the temperature of the interior of the body and that of the periphery. The less blood is carried to the skin, and the narrower the vessels become, so much the sooner will there be a difference between the internal and the external temperature in heat abstractions from the surface of the body. The chief problems shampooing has to solve, as

an antipyretic procedure, are then, according to this, dilatation of the cutaneous vessels, increase of the heat discharge from the skin, and overcoming the heat accumulation.

The temperature of the water used in shampooing should fluctuate between 8° and 16° C. (46·4° to 60·8° F.) It is not suitable to use any higher temperatures in shampooing, since they bring about a dilatation with much greater difficulty, and it is more difficult to allay heat retention and gain control over the body temperature by their assistance.

It is not generally possible to define accurately how long each shampooing should last. The measure for this is given by the colouring of the skin—an equal rose-tinted injection—and the cutaneous warmth, which one soon learns to estimate correctly by feeling the sheet on various parts of the body. Usually the proper effect will be attained in from two to five minutes. In cases in which the body temperature requires to be energetically reduced the shampooing may be continued for from fifteen minutes to half an hour, coarser sheets less wrung out being used. Even to anæmic patients, when we have found the indication for shampooing, it will not be more sparing to dip the sheet in warm water, since in that case the insufficient nervous stimulation will not be suited for the intended alteration in the nutritive processes.

It is impossible to establish in detail in which nutritive disturbances benefit may be expected from the application of this procedure. We must always keep before us the fact that, up to a certain degree, shampooing embraces the whole region of the operation of thermal and mechanical influences, and that according to the manner of carrying out this process will the mode of action thereof be subject to the most manifold variations qualitatively and quantitatively. Here also, as in every other therapeutic measure, it will be our object to establish as precisely and accurately as possible the nature of the nutritive disturbance, to adapt the mode of procedure to the circumstances of the case before us, and to graduate accordingly, as we have already evolved, the degree of nervous stimulation, of heat abstraction, and of mechanical interference respectively.

The contra-indications to this procedure are much more

limited; we will exclude it in all those cases where the mechanical interference necessarily combined with it is not practicable on account of hyperæsthesia of the dermal organ, wounds and ulcerative processes on the surface of the body, hyperirritability of peripheral sensory nerve endings, or great painfulness in inflammatory processes. We will furthermore avoid this procedure when a more definite indication for another procedure presents itself. In cases where it is our object to cause a powerful concussion or a rapid heat abstraction, we will of course make use of procedures which fulfil these indications more rapidly, in preference to shampooing.

The Wet Pack.

The technical order of procedure in carrying out this measure is as follows:—

A woollen coverlet or blanket of $3\frac{1}{4}$ metres' length and 3 metres' breadth for an adult is spread out evenly over a couch or bed; over this blanket is laid a coarse or fine sheet which, according to the required indications, has been plunged into cold water, wrung out more or less, and folded either once, twice, or oftener. The person to be packed now lies down upon the bed thus prepared, and is then quickly wrapped up in the folded sheet by the bath attendant in such a manner that the damp linen lies as smoothly as possible over every part of the body, with the exception usually of the head. It must be particularly watched that the linen is carefully pushed in between opposite cutaneous surfaces, that is, well between the arms and the trunk and between the legs, so that the damp sheet is everywhere in contact with the surface of the body; and it must also be observed that the sheet lies closely and evenly folded round the neck, otherwise parts of the body which are difficult to heat, and which do not at best produce very much warmth, may be covered by only very few layers of the damp sheet; this relates particularly to the feet, which, if they feel cold prior to the packing, must either be not at all included, or must first be warmed by means of dry friction.

As soon as the damp linen is everywhere in contact with the body—and this must be accomplished very quickly—the bath attendant, who, during this procedure, had best stand on the left-hand side of the bed and patient, seizes the opposite free depending portion of the blanket and carries it across the body, to which he must apply it as closely as possible, taking care that by judicious folding and

disposition of the material he can make it fit closely round the neck without tension. As soon as this has been accomplished the other portion of the rug is carried round the body in a similar manner, the free long end is drawn tight, and the lower end tucked under the feet.

Thereupon further blankets or feather beds are spread over the wrapped up patient—who now resembles a child in swaddling clothes—according as the rewarming is intended to be rapid or slow, and the heat accumulation to be more or less complete in extent. The free ends are well tucked in on both sides of the patient, and it is to be carefully observed that the chin always remains outside the coverings, so that respiration may go on uninterruptedly.

The respiratory organs must constantly receive a fresh supply of air, rich in oxygen, in order to obtain which it is usual to open a window immediately after the conclusion of the packing. The duration of the packing, the repetition of the process, the frequent or rare changing of the individual packings, the modifications of the whole procedure, and final cure necessarily combined with it, as well as some *general* procedure—such as a half-bath, shampooing, or a shower bath will be—must be defined by the indications directly on hand.

Further modifications of wet packing consist in enveloping the hairy part of the head, excluding the face, in damp cloths and woollen rugs as in a hood, or in packing only a larger or smaller part of the surface of the body ; accordingly we distinguish complete packings and incomplete or partial packings.

Distinctly to be separated from the wet packing just described is the so-called dry packing, which belongs to the category of diaphoretic measures.

Modus operandi.—The contact of the cold, wet sheet with the surface of the body brings about a more or less powerful nervous stimulation, according as the temperature is higher or lower, which, being conducted to the central organs, will cause alterations in innervation which will manifest themselves by alterations in respiration, of the cardiac activity, the frequency of the pulse, and in the lumen of the vessels. The cold water distributed in a thin layer in the meshes of the sheet will, however, soon have attained the temperature of the surface ot the body, and the sheet becomes warm as the bad conductors

surrounding the body in several layers prevent a greater loss of heat. In this way the surfaee of the body is soon enveloped by a moist, warm mediun. After some time the water begins to evaporate from the sheet, but the bad conduetors of heat obstruct the evaporation, and hence also the diseharge of heat from the surface to any appreeiable degree; there is therefore an accumulation of heat which stores itself upon the surfaee of the body. The damp sheet thereupon becomes heated to blood heat, and the body is now situated in a vapour bath at blood heat. The nervous stimulation, excited originally by the contact with the cold eloth, will, as the sheet beeomes gradually warmed, as gradually beeome toned down; the stimulation to innervation will hence be a more enduring one.

In respeet to respiration an inerease in the frequeney and depth of each single respiration, which is rather lasting, may be ascertained; it only beeomes slow again in the later periods of the packing.

The pulse rate, which was momentarily increased when the wrapping in the eold, wet sheet took plaee, will soon beeome slowed; and this retardation of the pulse is brought about, on the one hand, by the horizontal position of the body and the universal firm envelopment and eompression of its surface, which enforces absolute muscular quiet; on the other hand, by the reflex exeitation of the vagi. Johnson has shown that the pulse of a healthy person in whom, after a walk, 140 beats could be counted in the minute sank shortly after wet packing down to 84, and after an hour down to 60. In another experiment the pulse rate fell in the same time from 100 to 60, and in a third experiment from 100 down to 58 beats.

Petri ascertained in the first five to ten minutes of the packing a sinking of the pulse rate by 10 to 20 beats, and only after complete rewarming of the surfaee of the body a return of the pulse to its original frequency. If the paeking lasts any longer, say to diaphoresis, the pulse rate may even exeeed the original number of beats.

If we now eonsider the relation of the pulse rate to the respirations, the alteration will here also eonsist in the fact that fewer beats of the pulse always go to one respiration. Hence

the blood remains for a longer time in contact with the atmospheric air, and the interchange of gases will become more complete.

We mentioned above that the surface of the body is placed very soon in a vapour bath at blood heat. This vapour not only causes a relaxation of the skin and of the peripheral vessels, and thereby an extension of the bed of the blood current, a reduction in the circulatory obstacles to the heart, and, for this reason, a considerable slowing of that organ's activity, but also a soothing effect upon the entire nervous system through the quiet posture of the body, the absence of mechanical irritation, and the general warmth; for the peripheral nerve endings are situated in an unchanging medium which approaches the internal temperature very nearly, and is regularly distributed. Hence it will be observed that, in the absence of stimulants to innervation, the soothing influence extends itself from the periphery to the centres. By diverting blood from the inner organs to the periphery the impulses of innervation in the nervous central organs dependent upon the blood current will be very much weakened, and a tendency to sleep and great calmness during the continuance of the pack are the symptoms of these actions. In what way does the moist vapour itself act? may be asked. I have repeatedly laid stress upon the fact that the mode of action of this factor has been by no means sufficiently investigated as yet; what is known concerning it will be spoken of in another place.

In what way the perspiratory function of the skin is altered is also not sufficiently known to us. Even in water at the temperature of the blood or more, perspiration does not seem to be fully suspended; still less ought this to be the case in the vapour bath and in the moist vapour bath. On the other hand, it has been established by Röhrig's, Fleischer's, and other investigations that bodies in the form of vapour penetrate the skin. Whether the watery vapour penetrates the subcutaneous tissues and causes material alterations of the nutritive conditions and of the processes of diffusion, absorption and resorption, cannot be decided right away. We have only to remember the astounding actions of the longuette bandages or water poultices upon superficial processes in order to be

able to ascribe to wet packing from this point of view a mighty although not quite sufficiently precisionable action.

Investigations into metabolism during the wet packing are just as few and unreliable.

The action will, in this respect, be also a very different one according as we allow the pack to remain on for a longer or shorter period. In addition to this, the effect will certainly partly depend upon the influence of the procedure upon the body temperature, of which we shall presently have occasion to speak. That which is to be found in the older literature concerning this doubtful point in no wise fulfils the scientific requirements put to it.

The most reliable conclusions which one has hitherto been able to draw regarding the behaviour of the tissue metabolism during packing are obtained from the bearing of the body weight. Johnson's investigations have shown that the loss of body weight is only slightly increased during moist wrapping. Of course it must be taken into consideration that the not very accurate performance of the method might have had some influence upon this result, for Johnson never succeeded in calling forth diaphoresis, even though he continued the wet pack up to six hours. The reason must have been—and this appears almost with certainty from his descriptions—that he did not carry out the exclusion of air from the pack with sufficient completeness, and that therefore the heat accumulation upon the surface of the body was an insufficient one. A pack applied in a proper manner brings about a pretty considerable loss of weight, which is in direct proportion to its duration. There is here still a great gap to be filled in for the explanation of the action of wet packings.

It is of tantamount importance to the *modus operandi* of this procedure that we should know how long the packing should last, whether a fresh packing should take place, and how often it ought to be repeated. When we wish to operate soothingly upon the nervous and vascular systems, and without any very great deprivation of heat to obtain a dilatation of the peripheral vessels, we allow the pack to remain undisturbed until the surface of the body has become again completely warmed.

We must recognise, without opening the pack, whether the

surface of the patient's body has fully rewarmed itself, and if particularly the peripheral parts do not feel cold any longer; as this points to an irregular distribution of blood and heat, and must constantly be fought against. When we place the open hand upon the woollen coverlet in which the limbs of the patient are tightly rolled, we will feel with certainty after a little practice whether the parts lying underneath are normally or abnormally heated, or whether their temperature is still subnormal. We will recognise in feeling the body through the blankets whether the body temperature has returned to normal again, or whether it has already mounted above that temperature. In febrile diseases we find indeed that after 5 to 10 minutes the body temperature rises above the normal heat again; in this case then we must renew the packing after that interval of time. We must not let the heat accumulation exist long, but conclude the packing or exchange it for a new one, even before it comes to an acceleration of the circulation or to the actual breaking out of sweat. The moment for concluding the packing or renewing it is recognised by the fact that the subjective phenomena of stimulation or excitement on the part of the nervous system, which it is intended to allay, again become exalted, or that the number of beats of the pulse increases again after it has been considerably diminished before by the packing.

The pulse of the wrapped up patient is taken at the temporal or common carotid arteries. The renewed wet pack consists in the fact that the damp sheet is always changed as soon as the surface of the body has fully warmed the linen, and thus the breaking out of perspiration is prevented. In this way we convert the reflex stimulation of the vagi into a continuous one, and only very slowly and a little at a time abstract heat, only carrying off the quantities accumulated on the surface through diminished heat discharge, and keeping off mechanical irritation from the peripheral nerve endings; thereby attaining a soothing effect upon the whole nervous system, such as is obtainable by only few therapeutical measures in the same degree.

The renewed wet pack is an effectual method for the treatment of fever; it combines all the advantages of a successful

antipyretic procedure. By each of the preceding packings the excitability of the peripheral vessels becomes somewhat lessened; the primary vascular contraction in packing is unimportant and evanescent, since the surface of the body will soon have placed itself in thermal equipoise with the water distributed in the sheet. The passive vascular contraction is soon followed by a considerable dilatation of the vessels, in which case the blood at fever heat rushes from the interior of the body to the periphery, exchanging there its own temperature for that of the damp sheet, and returning with a reduced temperature to the internal organs to cool them down. Such a temperature reduction would surely not be an important or effectual one if the body were not in some other way deprived of a much greater quantity of heat. The blanket, which lies close to the body, does not prevent the evaporation of the water in the sheet, for even if the blanket were considered impermeable the evaporation in the air space between the coverlet and the sheet, and, further, between the sheet and body, would continue to go on without interruption. Since, therefore, a great quantity of heat is required to evaporate the water, the amount is drawn from the skin and the blood. The heat loss is however increased in yet another way; once the rough outer surface of the woollen coverlet has become heated much heat is lost by radiation therefrom. This can be plainly felt by the hand, and may be demonstrated by means of my calorimeter. Krieger has shown that when two tins of the same size are filled with warm water, and allowed to cool down, the one which has previously been tightly covered with flannel will cool down very rapidly, whilst the other which is left uncovered will retain its temperature for a much longer time.[1]

Yet another factor contributes towards increasing the heat loss or reducing the production of heat; by tightly enveloping the body the muscles are placed in a state of rest and inactivity, and in this way the formation of heat is lessened.

[1] This fact has been availed of empirically for a long time in the protection of ice by surrounding it with pieces of woollen texture; so useful is this little manœuvre in preventing the ice melting that the material is often removed only with great difficulty, and leaves some of its constituents adhering to the ice.—TRANSLATOR.

The body temperature elevated by fever is, however, not sufficiently reduced by all these factors in one simple wet packing, for we have seen that the fever often reaches its former elevation ten minutes after the first packing. The packing must now be renewed, and it is best to carry it out on another couch, placed close by, on which the patient is placed. A fever patient becomes warm again in every subsequent packing about 15 to 20 minutes later than in the preceding one, and the packing is repeated until a sufficient moderation of the fever has been achieved. This point is to be considered as reached when the patient, during the last packing, has required more time for the complete recovery of his heat, and his temperature does not soon rise above normal, and again when in the last packing a shivering fit of some duration, or even a rigor, has taken place. This is the sign that the packing must be discontinued. From 10 to 12 or more packings may be required for this purpose. In the last one the patient is allowed to remain from $\frac{3}{4}$ to $1\frac{1}{2}$ hour, by which time the skin generally becomes moist and warm, and in many cases perceptible, and even profuse, outbreaks of perspiration take place.

The most important matter to which attention must be paid in this form of antipyresis is the equal return of heat to all parts after each fresh packing. Attention must therefore be paid chiefly to the feet, the recovery of whose heat must be attained even by means of bags filled with warm water, warm cloths, and hot bottles if necessary. For reasons easily understood, the influence of individual packings upon the reduction of the body temperature is not very considerable. Hardly a litre of water will be found to have been contained in an ordinary rather coarse linen sheet, such as is usually applied to packing purposes, after it has been wrung out as required. If now the sheet has been immersed in water, say of 10° C. temperature, and we assume that after it has been spread out upon the blanket as required for the operation of packing, it still retains this temperature; and when we further assume that in the process of packing the sheet has become equally warmed throughout to the temperature of the blood at the expense of the body heat, there will

in this way have been drawn from the body by one sheet at most 27 calories.

From this heat loss there would, however, have to be deducted that amount of heat which was prevented from free radiation by the bad conductors. Even assuming a diminished formation of heat in consequence of the quiet attitude and the tight constriction of the muscular structures, the positive reduction of temperature could even then be only comparatively a small one.

When, therefore, we wish to reduce the body and blood temperatures effectively we must spread either two- or three-fold damp linen sheets upon the blanket, one over the other, and envelop the body in this multiplied, moist series of layers of linen, or repeat the packings as frequently as may be necessary for the attainment of the desired object.

When the body has sufficiently regained its heat in the last packing, and even when it has begun to perspire and the body temperature has been reduced to normal, the packing must still be followed by a cooling process, some general heat abstraction which concerns the whole surface of the body, such as a shampooing, a shower bath, or a half-bath, in order to counteract the relaxation produced in the skin and its vessels by the heat accumulation, or, in other words, the masses of heat stored up on the surface of the body must be abstracted therefrom. The appropriate cooling procedure does not even impair the real derivatory action of the packing, the vascular determination to the skin, or dilatation of the cutaneous vessels. It is hence explicable why the contact of cold water with a hot skin should cause a feeling of coolness, freshness, and comfort, whilst the contact of cold water with a normally warm or cool skin calls forth an unpleasant feeling of shivering, coldness, and even of pain.

But neither is it an easy matter to obtain contraction of the cutaneous vessels and expulsion of the blood from the periphery by this cold influence, for after the packing there exists that fulness of the capillaries which is wont usually to follow the cold stimulation much later, as well as the great accumulation of heat in the skin, and the high degree of relaxation of the cutaneous vessels. The cutaneous vessels

will only become contracted when the cold impression is a more lasting one, and when the temperatures of the body and of the blood have been reduced to subnormal then also will the phenomena of the expulsion of blood from the surface make their appearance. But if the cooling process be interrupted, so long as the skin is still vascularised and the pulse rate has not fallen considerably under the normal, the derivatory action of the wet pack will be a rather durable one. Why packing is such a capital antipyretic procedure is easily comprehended when we remind ourselves of the reactionary law according to which the rapidity with which heat is regained depends in the first place upon the rapidity with which the heat was withdrawn, and in the second upon the amount of the mechanical irritation. Since, then, the heat abstraction in packing is quite a gradual, and the stimulation combined therewith quite a mild one, the reaction (resumption of heat) will also be extremely slow.

Indications.—Apart from the antipyretic action of packing, of which indeed we had to take cognisance in speaking of the *modus operandi* of this procedure, it will also find application in numerous chronic forms of disease. In particular there are first those so-called erethic individuals in whom every action, every interference, is followed by a turbulent reaction, which are peculiarly fit subjects for this form of application. Retardation and lowering then of pathologically exalted and accelerated metabolism may be set down as the most general indication for the use of wet packing.

Wherever it is necessary to stimulate the function of the skin and to alter the nutrition of the dermal organ, there it will be found suitable to make use of periods of longer or shorter soaking in the wet sheet.

We have already drawn attention to the soothing of the entire nervous system by the prolonged action of the moist vapour upon the peripheral sensory nerve endings, so there will be quite a long series of nervous affections, especially of those displaying the character of great irritability, in the treatment of which this procedure will hold its own. Well-nigh specific, however, will be the action of the wet pack as a measure to steady the heart's action and the circulation. From the intense vascularisation of the skin caused by this procedure it

may be considered as derivatory, and from this point of view it will be able to find application in affections of numerous parenchymatous organs.

By its unavoidable combination with other procedures, and through the exaltation of the excitability of the peripheral cutaneous nerves in the warm vapour, the region of applicability of this procedure becomes still greater and more manifold. In detail this may be deduced from the manner of its action just now described, although it may have been imperfectly so.

THE METHODS WHEREBY SWEATING MAY BE INDUCED.

Sweating is induced either by a direct supply of heat or heat accumulation, and prevention of the heat loss. As the best means of supplying heat, directly, may be mentioned hot air and steam box baths; as a means of accumulating heat, dry packing, which is also known as the Priessnitzian 'sweating press.'

Steam Box Baths.

Method.—It is, we presume, superfluous to describe minutely the steam boxes which are used for sweat baths. That which is common to the various most useful apparatus consists in a steam-tight box which, according to its destination, represents either a steam box or a steam armchair, or else a receiver for some part of the body—e.g. the foot or the arm. These appliances are now heated by means of various steam-generating apparata which are outside the boxes, and whose steam pipe opens into the box, or else there is some heating mechanism in the box itself, which then consists of either a simple or a compound spirit lamp, and heats the air space inside the box. (Alcohol vapour bath, hot air bath; *étuve sèche* of the French.)

It is a well-known and oft-tried and proven fact that much higher degrees of heat may be borne in a dry atmosphere than in one which is pregnant with watery vapour, and that, in the water bath, even the slightest degree of heat above the blood heat, no matter how slight, is quite unbearable. This originates from the fact that the dry air communicates its heat much less easily to the living body, and that in the dry warm air there is a continuous evaporation from the skin and the lungs which confines a greater amount of heat, and thereby causes a greater cooling-down than the *guttatim* excretion which takes place

in a room saturated with aqueous vapours. Whereas we have instances that, in dry heat, a temperature of 125° to 126° C. (257° to 258° F.) was borne for several minutes, 68° to 70° C. (154·4° to 158° F.) is the highest temperature which can be borne in the vapour bath, and that only for a few moments, too, by those habituated to this form of bath, and it is always endured under painful sensations. In the vapour rooms, we may as well add at once, so great a heat can by no means be borne as in the steam box. When the head is not inside the sweating box, 55° C. (131° F.) will, according to Rapou, still be endurable, 65° to 70° C. (149° to 158° F.) will be unpleasant, and 70° to 75° C. (158° to 167° F.), according to De la Roche and Berger, will still be endured, but burning in the skin and great excitement will set in; in this case also, practice creates greater powers of endurance.

In the commencement, 36° to 38° C. (96·8° to 100·4° F.) suffice; rarely only is there any necessity to go higher than 40° C. (104° F.); whilst it is only exceptionally that temperatures up to 45° C. (113° F.) will be made use of. The duration of a single steam box bath is seldom longer than twenty-five to thirty minutes; it will usually, however, have had a sufficient diaphoretic effect after fifteen to twenty minutes.

Dry Packing.

Another method of exciting perspiration consists in preventing heat loss by bad conductors of heat. It is best performed in the manner first practised by Priessnitz of dry packing.

Method.—The naked body is rolled up in the blanket alone, either with or without including the hairy scalp—the face, of course, always remaining free—in a manner similar to that described under the head of 'Wet Packing.'

The thus enveloped patient, who now resembles a mummy, is then covered with plenty of heavy blankets, feather beds, &c.

Modus operandi.—By this procedure the greatest possible heat accumulation is effected, and the pressure which at the same time is exercised upon the surface of the body by the tight wrapping of the blankets, relaxes the muscles to the utmost and puts them out of action. The chief direction of the blood current will be diverted towards the skin. The fine little woollen hairs of the blanket irritate the skin, which has

become more irritable through the heat accumulated upon its surface. The cutaneous vessels relax, and the circulation in the skin is accelerated in the warmth, whilst the blood itself is not relieved of the masses of heat which it has carried to the periphery, and so returns to the internal organs without being cooled down, elevating thereby their temperature by 0·5° to 1° C. The warmer blood acts as a stimulant to the heart, probably by excitation of the peripheral nervous centres within it, and likewise upon the nervous centres presiding over the secreting nerves of the skin.

After slight appearances of congestion and elevation of temperature, perspiration sets in, which carries off the superfluous heat accumulated upon the surface of the body, lowers the body temperature again, and brings back the phenomena on the part of the organs of circulation and respiration to normal again; and, by the secretion of sweat, which can be at will controlled as to its magnitude, the constitution of the blood, the current of the fluids in the tissues, the processes of endosmosis and exosmosis—in short, the whole tissue metabolism—are most powerfully influenced.

It does not appear to me to be quite identical whether, as Fleury states, by direct supply of heat, as in the vapour bath, or by heat accumulation, as in dry packing, we call forth the secretion of sweat. It seems to me more energetic, or at the least a very different matter if the heat necessary to elevate the cutaneous and body temperatures so as to cause sweating is produced by the body itself than if it be supplied to it from without. The only objection which Fleury raises to dry packing consists in that it often takes hours (so it is alleged) before the body perspires under this procedure; that it therefore makes the patients very nervous and impatient from having to lie often for hours in one position, and is combined with manifold disadvantages.

Were this really the case, the process of dry packing would be a very disagreeable and often deleterious measure; there are, however, certain aids to promote sweating and accelerate its advent which we may in a case of the kind advantageously employ. I will at once state that Priessnitz's 'sweating press' as described must be restricted to the treatment of those cases

in which it is desired to obtain influence over the constitution of the blood and the condition of the interstitial fluids, over the fluid metamorphoses as well as absorption and resolution—in a word, chiefly in affections of the blood and fluids, and in dyscrasic processes. One absolute condition, however, has to be strictly observed, and that is that the patient be able to walk about before the commencement of the procedure. It is further to be noted that the body is much more disposed to perspire readily in the afternoon than in the forenoon. In accordance herewith I order the patient whom it is intended to pack to take a walk in warm and heavy clothing, a rather stiff up-hill clamber being the very best for the purpose. Whilst he is thus engaged, the blanket in which he is to be wrapped is being warmed either in the sun or by some other means, and as soon as the patient returns from his exerting walk, when, as a rule, he will be already perspiring, he must undress rapidly, be packed into the blanket prepared for him with the utmost celerity and covered with other blankets, rugs, &c.

Under these circumstances it seldom lasts more than a few minutes before the patient begins to perspire profusely. This perspiration can now be kept up, as required, for a longer or shorter period. I seldom allow dry packing for the purpose of exciting perspiration to last longer than $1\frac{1}{2}$ to 2 hours, and have observed a loss in body weight thereby which amounted at the very least to 0·9 kgr., or more than $1\frac{3}{4}$ lb.; and during this period of sweating I cause a goodly quantity of fresh water to be drunk, usually at short intervals. In addition to this, I take care that an unlimited supply of fresh air is kept up, usually by opening the windows: always, however, observing that no draught plays upon the patient.

Every promotion of sweating, as well in the blanket as in the vapour bath, must of necessity be followed by a heat-depriving procedure, which has the object of moderating the violent vascular determination to the skin which was caused by the perspiration and to conclude that process by contracting the relaxed and dilated vessels; also to abstract the heat accumulated upon the surface of the body and to reduce the temperature to normal or even sub-normal; furthermore, to allay the still accelerated action of the heart caused by the profuse perspi-

ration, to prevent relaxation of the dermal organ, exalt innervation by reflex from the sensory peripheral cutaneous nerves, and thereby to brace and add tone to the whole organism.

The combination of heat abstraction with the sweat stimulation allows of a long continuance of this treatment, but it is not a matter of indifference what form of heat abstraction is resorted to after the stimulation of sweat secretion. The most astringent and rapidly heat-depriving procedures which exercise a great influence over the vessels relaxed by the heat and the exhausted nerves, are here the most suitable. The coldest water obtainable, and which is allowed to strike the body with much mechanical force, will fulfil the requirements best, its period of application being again gauged by the object it is desired to accomplish. The cold shower and whole bath, as well as the half-bath, are the proper modes of application. That which is common to the action of heat supply, whether in the vapour bath or in heat-accumulative processes such as the dry pack, consists further in an elevation of the body temperature, which depends upon individual circumstances also, and will be the higher the later perspiration sets in.

It is easy to send up the body temperature to a high degree of pyrexia by means of the vapour bath; and I have also observed in dry packing an increase of heat up to 1° or 1·5° before perspiration broke out. The property then of regulating its own temperature, and the tendency to maintain its normal temperature under all circumstances, are taken from the body by heat accumulation or increased heat supply, and an elevation of the body temperature follows. Even this artificial elevation brings on symptoms similar to those of fever, and these are subjectively great thirst, dry mouth, feeling of disgust, a reddened face; brilliant, deeply-injected eyes; sensation of weight in the head, giddiness, sometimes disturbances of the intellectual faculties, depression, languor, symptoms of cerebral oppression, fainting fits in very high degrees of temperature, dulling of all the senses, rolling about of the eyeballs, gnashing the teeth, convulsions, &c.

The influence exerted upon the nervous system at the commencement of increased heat supply is one of excitement; in long continuation of the supply, a depressing one. The in-

fluence upon the circulatory system consists in an acceleration of the beats of the heart; an increase in volume of the higher tempered masses of fluids; an increase of pressure in the vascular system, which is sometimes lessened by relaxation of the vessels and altered blood distribution in the organism; over-distension of the cutaneous vessels, and relative oligæmia in the internal organs. Metabolism also displays alterations similar to those in fever—namely, increased excretion of carbonic acid and increased formation of urea. The secretions of the internal organs decrease, and only upon the advent of profuse sweat secretion do the remaining symptoms of fever vanish, together with the elevation of temperature.

Indications.—Sweat-promoting procedures then, are indicated as a dietetic measure in neglected states of the skin and disturbances in the function thereof. This may often be caused by horny and dead layers of the epidermis, which adhere mechanically and displace the openings of the excretory ducts of all the glands, as well as by accumulated dermal fat, dirt, and the remains of evaporated perspiration. Here very often the interchange of gases by the skin, which undoubtedly stands in direct proportion to the thickness and porosity of the layers covering the most superficial blood-vessels, is mechanically lessened in intensity. *Numerous skin diseases may depend upon such a neglected condition of the skin.* The amount of blood in the dermal organ diminishes together with its lessened function, and irregular blood-distribution and hyperæmia of internal organs are the consequences thereof.

A greater irritability of the cutaneous nerves, too—to which all the diseases from '*catching cold*' are to be attributed—is intimately related to neglected care of the skin. In all forms of disease thus originated, the vapour baths and sweating procedures must accordingly be valued as dietetic and curative measures. In a similar manner as in diseases from cold, sweating cures are adapted to the treatment of *rheumatic* affections, and they will also find application as *derivative* measures, since the increased excretion of water by the skin will probably[1] be of influence in promoting resorptive processes within the organism.

[1] The word 'undoubtedly' would have been much more appropriate here,

Hence we shall make use of this method in the treatment of dropsies and stationary inflammatory products. No less may such a method, which increases the secretions of the body, be useful in numerous dyscrasic processes; wherefore gouty affections, scrofula, syphilis and obesity will be often beneficially influenced in this manner.

Contra-indications.—Like every other measure, dry packing may by its immoderate use prove deleterious even to healthy individuals. The daily irritation of the skin may lead to manifold forms of eruptions, and the excessive sweat stimulation to disturbances of nutrition, to *retrograde metamorphosis*. In all irritable nervous affections this powerful nerve stimulant is to be avoided, and certain conditions of the circulatory apparatus and organic diseases of the heart forbid its use, which is also contra-indicated in all forms of inflammation, all acute diseases, and, in a word, everywhere where severe sweating would be out of place—e.g. in consumptive diseases and pseudo-plastic processes.

PARTIAL BATHS.

We now turn to the more important forms of partial baths. A rarely used form of bath is the so-called

Occipital Bath.

Method.—In this bath the occiput is immersed in a vessel like a basin, which has a hollow cut out of its rim for the reception of the nape of the neck of the patient, who assumes the horizontal position. This vessel may also be furnished with an appliance for letting the water in and off.

Modus operandi.—The manner in which this bath acts has not yet been physiologically investigated. Empirically it seems

as of all the measures we in Great Britain adopt for promoting the resorption of fluids, diaphoretic treatment is undoubtedly the best, and the hot air bath has been long recognised and made use of in anasarca, especially from chronic kidney disease, and effusions, by British physicians. It has not been adopted empirically either, for it is surely one of the most natural occurrences that promoting the excretion of water by the skin should decrease the amount of water within the body, whether that amount was previously normal or pathologically increased, and stimulate the activity of the absorbents, as we shall find to be the case later on (see p. 599 *et seq.*)—Translator.

to be of most service in excitable conditions of the sexual sphere, and has been frequently made use of in youthful persons who suffered from nocturnal emissions. Although I have had frequent opportunity of using this procedure, I have not as yet arrived at any conclusion as to its value.

To the category of the most suitable forms of baths, although its area of applicability is a narrow one, belongs

The Elbow Bath.

In it, the region of the elbow is immersed in water usually of a very low temperature, the fore and upper arm being appropriately supported at the same time. Elbow baths are used as antiphlogistic remedies in inflammatory affections of the forearm, the hand, and the fingers.

Modus operandi.—The contact of the very superficial ulnar nerve with the cold water, and the contractile stimulation which is given to the brachial artery above its bifurcation by the immersion of the elbow in the bath, seem to be the reasons for the efficacy of this procedure. It acts loweringly upon the blood supply and the temperature and on the parts peripheral to the immersed portion of the body; it is a powerful antiphlogistic agent to these parts, and therefore finds its indication in phlegmons, whitlows, and erysipelatous inflammations.

Duration of the elbow bath: quarter to half an hour and longer.

As a most admirable revulsive curative measure the

Hand Bath

must be here considered and described. Its forms of application and administration are indicated by the name; in any vessel which can hold water, in every basin, hand baths can be exhibited.

The action will of course be more intense when there is a constant supply of fresh water to the immersed hands and the used water can flow off.

Hand baths have been particularly useful to me, cold as well as hot, in numerous nervous affections of the respiratory organs, e.g. asthmatic attacks. It seems as if the sensory nerve endings in the hands which are involved in this procedure were

in reflex relationship to the nervous central organ for the function of respiration.

The Sitz Bath[1] (Hip Bath).

One of the most used and most effective local hydriatic procedures is that form of bath known as the sitz bath.

Method.—The mode of administration of the sitz bath is too well known to need description here, and the procedure is sufficiently distinguished by its name.

Modus operandi.—Here more than in any other procedure the necessity exists for preparing the organs to resist the congestive retrostasis, since in addition to the thermal stimulation the doubled-up position in the sitz bath facilitates the congestion of the head, as flexing the thighs upon the abdomen causes a bend in the arteries, and hence there will be a circulatory obstruction to the supply of the lower half of the body. In individuals prone to congestion we also observe the face becoming red and hot if this has not been anticipated and prevented by sufficient energetically carried out cold applications to the head.

The mode of action of the sitz bath will, and must be, a different one according to temperature, duration of its application and agitation or stillness of the water.

We distinguish the influence of the cold and of the warm sitz bath upon innervation, blood pressure, circulation and respiration, its local and its general action upon the temperature, and finally its influence upon metabolism and the alteration of local and general nutritive processes. The agitation of the water also and a change in its temperature is of influence upon the *modus operandi*. Let the effect of this procedure upon the blood distribution and circulation now be subjected to an examination. It is found upon placing the body in the sitz bath that an increase in volume takes place in the arm confined in the plethysmograph; a determination of blood to the head, weight, feeling of heat or even lancinating

[1] The term 'sitz bath' has become incorporated in the English language, why, it would be hard to say, for it would be one of the easiest things imaginable to give the procedure its English name; however, as a certain idea is conveyed by the term, it had better be adhered to.—Translator.

pain in the crown of the head, more lively injection of the conjunctivæ, muscæ before the eyes, noises in the ears, and often giddiness follow ; there is often a break in the respirations, one deep spasmodic inspiration being taken and much accelerated and deeper breathing following. The radial pulse shows increased tension of the arterial tube, and sometimes acceleration and irregularity of the beats, which are however slowed down again after a short time in the bath.

All these phenomena justify us in assuming that the peripheral nerve endings of the skin of the sexual organs, of the perineum and the inner surfaces of the thighs, and the gluteal region which are involved in the bath, stand in physiological reflex relation to the nervous central organs of the abdominal vessels, and that the tonus of these vessels can be influenced from these parts. Since the abdominal vessels are the most important factors in the regulation of the blood pressure, *we are able to deduce nearly all the phenomena called forth by the cold sitz bath, most naturally from a reflex excitation of the splanchnic nerve.* But we have also to make mention of yet another mode of action of the sitz bath upon the blood distribution. Amongst the most varied thermal impressions, dependent upon their duration and intensity and upon individual irritability, we also find the opposite phenomena making their appearance. By sitz baths we can obtain dilatation of the lumen of the abdominal vessels and derivation from the head and thorax ; once indeed as the after effect of the primary vascular contraction—as a reaction—and secondly by a direct heat influence as well. In a hot sitz bath of say about 38° C. (100·4° F.), a little over blood heat, we observe that the volume of the arm within the plethysmograph usually diminishes considerably.

Hence we can enforce by sitz baths also an increase of the capacity of the abdominal vessels, and we are then acting derivatively upon the upper half of the body, the head and thorax. In another way, however, we can also prove the influence of the cold and hot sitz bath upon the circulation, and that is by practising thermometry upon non-immersed parts of the body. The temperature of the axilla mainly rises at the moment of entering a cold sitz bath, and only after its comple-

tion is it wont to sink below the original level. It behaves differently however during hot sitz baths; here also it rises at the moment of entrance, although most inconsiderably, and a few minutes thereafter the heat of the axilla begins perceptibly to decrease. This decrease lasts some time, to rise only upon longer duration of the bath or after its conclusion. The grounds for the elevation of temperature and decrease are the same as those for the increase and decrease in the volume of the arm, namely, on the one side, collateral hyperæmia following stimulation, upon the other collateral anæmia resting upon lessened stimulation of the splanchnic nerve; and lastly, reactionary determination to the immersed parts. These are the chief vasomotorial effects of the sitz bath.

The equalisation of the temperature between the immersed parts of the body and the fluid in the sitz bath is of influence upon the local as well as upon the general temperature. Concerning the influence of sitz baths upon the local temperatures, reliable statements are only very sparsely scattered in literature.

My experiments, which I shall display in a more concrete form in the following table, teach us that cold sitz baths of short duration lower the rectal temperature after the bath by about 0·1° C. in the mean. Ten minutes after a bath of ten minutes' duration, the mean rectal heat was higher than before the bath, and this elevation of temperature maintained itself for more than an hour. Two hours later the heat of the large intestine had again fallen below the original temperature, and thus maintained itself for several hours. Short cold sitz baths therefore cause a local reduction of temperature, which is, however, followed within the first half-hour by a local reactionary elevation, which becomes toned down in the second hour, and is then succeeded by a moderate fall, which lasts several hours.

Cold sitz baths of longer duration, up to thirty minutes, lower the temperature of the large intestine much more than those of shorter duration. The local refrigeration also lasts much longer, the reduction of temperature being often still recognisable after an hour or more. Subsequently an increase of temperature takes place, which lasts about two hours, with a

Table showing the mean course of the temperature in the rectum and axilla before, during and after sitz baths of different temperatures and duration.[1]

Time: Hours	Time: Minutes	Sitz bath at 10° C. Duration 10 min.			Sitz bath at 10° C. Duration 30 min.			Sitz bath at 36° C. Duration 10 min.			Sitz bath at 36° C. Duration 30 min.			Sitz bath at 20° C. Duration 30 min.		
		Rectum	Axilla	Mean out of	Rectum	Axilla	Mean out of	Rectum	Axilla	Mean out of	Rectum	Axilla	Mean out of	Rectum	Axilla	Mean out of
Prior to immersion		37·20	37·00	Ten experiments	37·19	3[illegible]·9	Six experiments	37·14	36·81	Four experiments	37·21	36·93	Four experiments	37·17	36·94	Ten experiments
During the bath		—	37·2		—	37·29		—	36·72		—	36·88		—	36·99	
—	10′ after	37·1	37·14		36·94	37·24		37·32	36·74		38·44	36·91		36·88	36·96	
—	20′ „	37·3	36·94		36·97	36·89		37·25	36·71		37·96	36·90		36·80	36·95	
—	30′ „	37·24	37·02		36·99	36·93		37·21	36·70		37·14	36·81		36·95	36·95	
1 h	— „	37·22	36·95		37·20	36·89		37·04	36·64		36·95	36·79		36·89	36·94	
2 h	— „	37·18	36·91		37·20	36·90		37·10	—		36·99	36·90		36·92	36·91	
3 h	— „	37·21	37·0		37·05	—		—	—		36·71	36·74		36·95	36·92	
4 h	— „	—	—		36·91	36·91		—	—		—	—		36·97	36·90	
5 h	— „	—	—		36·98	37·0		—	—		—	—		—	—	
6 h	— „	—	—		36·94	—		—	—		—	—		—	—	

[1] Before and after the bath, rest.

N.B.—Compare figures with accompanying table of F. and C. temperatures.

mean thermometrical elevation of 0·1° C. After this period there is a compensatory sinking of the temperature, which is still recognisable six hours later in individual experiments. Cold sitz baths long in duration then cause a lower and more permanent reduction of temperature. The reaction sets in later, is less intense, and is followed by a less pronounced compensatory decrease of temperature.

The hot sitz baths, closely approaching the blood heat, of shorter or longer duration, heated the large intestine directly, apparently through diminished loss of heat and heating of the peripheral strata. The maximum temperature was therefore found immediately after the conclusion of the bath in this case, and it was then followed by a continuous decrease.

The most important therapeutical results were obtained by sitz baths of a mean temperature of 16° to 25° C. In the longer and shorter periods of application of this form of bath, the average showed no reactionary warming of the rectum. A so-called *tempered* sitz bath, whether long or short in duration, was followed invariably by a more or less permanent reduction of temperature in the deeply-situated parts of the immersed body, e.g. the rectum. The duration of this reduction stood in direct proportion to the length of the immersion. Often after four hours the primary temperature had still not been regained.

It seems, therefore, that cool and tepid sitz baths do not exercise any very powerful nerve stimulation, and that they bring about a lower and more enduring reduction in the temperature of the rectum, a greater discharge of heat, and a more complete equalisation of the temperature difference between the media touching each other only after prolonged action and according to simple physical laws.

The influence of sitz baths upon the general body temperature will be even less extensive than upon the local. The prolonged contact of the skin of the very vascular parts of the body submerged, with the heat abstracting or supplying medium, could here alone bring about the equalisation of the temperatures.

Indications.—Experience corroborates the indications which may be deduced from the physiological processes just described

for the sitz bath. The cold sitz bath will be suitable in every case in which, primarily, we propose calling forth an acceleration of the circulation in the portal vein and its ramifications; and secondarily, intend causing an increased quantity of blood to be supplied to the external genitals and the organs of the pelvis, thereby raising their temperature and local tissue metabolism.

Indications are also found for the use of this bath in the manifold forms of torpid circulation in the abdomen, and in passive congestions of the liver and spleen. It will, in addition, be also suitable on account of its primary and secondary action in all forms of disease of the urinary and sexual organs and lower end of the intestinal tract which are accompanied by disordered innervation, a diminished blood supply, relaxation of the tissues, sluggish function and retarded metabolism.

In paretic and paralytic conditions of the sphincter of the bladder and detrusor urinæ and similar conditions of the sphincter ani, as well as in all forms of impotence, spermatorrhœa, and prostatorrhœa, which are accompanied by want of tone in the particular parts, we will therefore make use of the sitz bath in this form.

In the female it will be torpid conditions of the uterus and its appendages, prolapsus, flexions, various forms of leucorrhœa dependent upon anæmia or passive congestions, amenorrhœa, arrest of menstruation and passive metrorrhagia which may possibly find a remedy in this form of the sitz bath.

Where it is necessary to endeavour to bring about a derivation of blood from higher organs, as in congestions of the head and lungs, active hyperæmia of the liver, chronic and atonic, gastric and intestinal affections, loss of appetite, constipation and flatulence, we will be able to make use of this bath appropriately.

Strongly contra-indicated will this form of bath be in all active hyperæmias or inflammations of the abdominal and pelvic organs, e.g. great sexual irritability, in frequent pollutions, vesical spasm and catarrh, inflammations of the bladder, and profuse metrorrhagia and menorrhagia.

The more prolonged cold sitz bath acts much differently. The character of its action consists in reduction of temperature,

diminution of nerve irritability, retardation of the nutritive processes and elevation of vascular tension. Tonic, styptic, anticongestive and antiphlogistic actions are developed by warm sitz baths at a temperature of 11° to 18° C. and from half an hour to an hour in duration.

The more prolonged cold sitz bath is therefore resorted to in intestinal, vesical, urethral and uterine irritations and inflammations, in inflamed piles, in inflammation about the urethra and the rectum (periurethritis and periproctitis), in inflammations of the prostate and some forms of acute gonorrhœa, further in gastric affections, and it is *quite a sovereign remedy* in the various forms of diarrhœa and even dysenteric processes, particularly when combined with previous cold shampooing and a wet abdominal bandage thereafter. In vesical catarrh with severe tenesmus, and in uterine colic, this form of the sitz bath is contra-indicated, as the muscular tension and the painfulness would be thereby much increased.

Warm and even hot sitz baths are to be used in those cases in which we desire to lower exalted excitability in the nervous system, to moderate too tonic or spastic contractions of muscular formations, and to reduce the tension of the vessels; in short, when we wish to produce relaxation.

Indications.—The short warm or hot sitz bath only rarely finds application, but on the other hand *the more prolonged warm and hot sitz bath* has proved exceedingly useful in many forms of spasm and colicky pains in the male and female, according to numerous experiences.

I have found the hot bath, prolonged at 32° to 38° C. for one or two hours and longer, very effectual in many cases in allaying the severe, unpleasant, and often very painful tenesmus of vesical catarrh, or appearing as the result of gonorrhœa or heavy cold, and also after certain dietetic excesses (heavy drinking of fresh beer or recent wine, &c.), as well as in the numerous molimina of menstruation, particularly when in the form of menstrual colic. It usually facilitates the appearance of the bleeding in menstrual colic, and can be applied, with the necessary degree of caution—rest in bed afterwards—even during the catamenial period, particularly when there is too small a flow of blood.

Finally, it is incumbent upon us not to forget the, therapeutically, most important form of the sitz bath, namely *the tempered sitz bath of* 18° to 25° C. The general character of its action is, as we mentioned above, *one of gradual and lasting reduction of temperature with absence of any considerable reaction.*

Indications.—The tempered sitz bath, by its *local antiphlogistic action*, will often bring about a cure, especially in its prolonged form, in chronic gonorrhœa, stubborn leucorrhœa, infiltration of the uterus, chronic metritis unamenable to treatment, catarrh of the bladder, inflammation of piles, ovarial irritation and oöphoritis, or will at least cause some improvement in the phenomena of these diseases.

The Foot Bath.

Method of Administration.—A small, wooden tub, about 12 cm. long, is connected by means of a flattened tube, which opens about 3 cm. above the bottom, with the water supply of the house, or an elevated water reservoir. On the side opposite the opening for the tube, two or three circular holes, about $1\frac{1}{2}$ cm. in diameter, are pierced in the walls of the tub.

In using this running foot bath, the feet are to be so placed in the tub that the toes point towards the inlet. A valve which is attached to the supply pipe is opened, and the water now pours in a broad, horizontal stream over the feet in the vessel. The water flows off by the outlets as rapidly as it flows in ; the depth of water in the vessel therefore never exceeds from 3 to 4 cm.

The foot bath must be continued until the cutaneous vessels of the feet have been dilated to the utmost possible extent. Sometimes the mechanical influence of the running water does not suffice for the attainment of this object, and the feet must therefore either be continuously rubbed against each other, or be vigorously chafed by the bath attendant. The dilatation of the cutaneous vessels will be facilitated by exposing the feet to a powerful horizontal *fan douche* after a longer or shorter period of exposure to the influence of the flowing water. By this means it is invariably possible to redden the skin over the feet actively and regularly up to the ankles.

Modus operandi.—If we place a thermometer in the ear, and another in the axilla, and from minute to minute during the application of the foot bath, observe them carefully, we will find that, during the first two minutes of the procedure, the temperature in the external auditory meatus rises by 0·1°, returns after four minutes to the original level, and begins to fall after a further five minutes, so that after ten minutes' duration of the foot bath the temperature of the external auditory meatus may be lowered by from 0·5° to 0·6° C.

In the axilla the temperature rises after the first two minutes, by about 0·05°; then falls again to the original level, at which it remains constant, ten minutes later, during the continuance of the bath.

This coincidence in point of time of an elevation of temperature in the meatus, with the indication of a similar thermal commotion in the axilla, justify the assumption that retrostasial congestion might be the cause of this phenomenon.

The first cold impression upon the feet causes an extensive momentary vascular contraction in the skin, which manifests itself as retrostasis in an increased blood supply, and an alteration in the temperature of remotely situated parts of the body caused thereby.

We must therefore exert ourselves to prevent a retrostasial congestion to those vascular regions in which increased blood supply and elevation of pressure might not always be attended by safety. The vessels of the head and cerebrum deserve extra caution in this particular, since an elevation of pressure in them may be followed by deleterious effects. The action of the foot bath itself must be looked upon as a so-called revulsive action of the peripheral cold stimulation.

The sinking of the temperature in the external auditory meatus can hardly be explained otherwise than by the reflex influence of the thermal cutaneous stimulation, exercised during the cold foot bath upon the vessels and the circulation in the head.

The cold stimulation, even though it may have expanded to hyper-stimulation at the point applied, or have stimulated the inhibitory nerves, must here act only as a contractile stimulus to the vasomotors for other parts of the vascular

nervous system, and thereby have caused the corresponding vessels to contract. This view is supported by a contraction of some conjunctival vessels observed during the cold foot bath. The vascular contraction, therefore, is the reason of the diminished blood supply to the head, and this causes the fall in the temperature of the external meatus.

When we consider that the loss of tension in such a small vascular region as is afforded by the skin of the feet, could not possibly alter the tonus of the whole system of blood vessels, there can be no doubt that such local stimulation, involving as it does only a small number of vessels, does not act *by derivation* of blood from the head. The contractility of the vessels would, in any case, suffice to satisfy completely the increased requirement of blood in the skin of the feet.

Naumann has brought the proof that such topical stimuli influence the circulation in other parts of the body by way of the nervous system, by means of an experiment in which he was in a position to influence the circulation in the remainder of the body of a frog, which was attached to the web only by means of the sciatic nerve, by a local stimulation applied to the web.

The view that the local heat abstraction in the feet had sufficed to lower the temperature of the blood and body so far as to give an explanation of the fall in the aural temperature, would be still less justifiable, for this must have been certainly indicated and recognised by a corresponding fall in the axillary temperature.

Indications.—The cold foot or sole bath will be found very useful *in habitual coldness of the feet,* whether caused by spastic contraction of the cutaneous vessels in the lower extremities, or by passive conditions within them. Many forms also of *angio-paralytic sweating of the feet* will find their remedy in short foot baths of cold running water.

It is a long acknowledged fact in hydrotherapeutical experience that the cold foot bath is useful in headache, promoted by various causes. Those forms of headache, in particular, are allayed with almost physical accuracy by means of this procedure, which originate in congestions to the head, and in which there is an increased blood supply to the brain or its

membranes, as well as all those conditions which are characterised by elevation of the temperature of the head, by more lively injection of the conjunctivæ and heightened colour of either one or both sides of the face and ears. The peristaltic action of the bowels is also frequently promoted by the procedure in question; in some forms of sluggish function of the intestine, we will therefore find an appropriate means of treatment in this form of bath.

On the other hand we must take good care to avoid using foot baths in any affections of the urogenital system. Vesical catarrh and a tendency to spastic contraction of the bladder, are those which are usually most aggravated by the foot bath; anæmia of the brain of any kind, sclerosis of the cerebral vessels, and allied processes also contra-indicate the use of cold foot baths.

THE COMPRESSES.

General.

Of the various forms of compresses which belong to the most important and most used hydrotherapeutical measures, *cooling* and *heating compresses* are distinguished; the former, as their name implies, are intended to reduce the temperature of the part upon which they lie by various degrees, and thereby to influence the local nutritive processes. The method of application is here by no means a matter of indifference. Refrigeration, or the local reduction of temperature, is, as we have seen, of influence upon innervation and the circulation. By its action the processes of diffusion and cell life are retarded and arrested, and the blood supply is diminished, whereby the passage of white and red blood corpuscles from the vessels, in inflammatory and exudatory processes, is diminished or kept quite in check. In a word, the physiological and pathological vegetative and nutritive processes are arrested. Chemical and fermentative processes, and those of decomposition, are altered more or less according to the degree of the reduction of temperature.

As supplying general indications for the local application of cold, all local processes may therefore be taken which rest upon hyperæmia, congestion, or inflammation, and all processes in which pain, heat, or exudation require to be combated or prevented.

Processes quite the reverse of these, are called forth by *localised heating* or *direct heat supply*, by means of *stimulant* and *hot compresses* or fomentations.

Diffusion, cell life, blood supply, the transit of red and white blood corpuscles through the walls of the vessels, metabolism, the formation of tissue, in short, the physiological and pathological vegetative and nutritive processes, decomposition, fermentation, and organic operations, *are all promoted and accelerated by heat.*

In every form of local anæmia, swelling, and solid exudation, as well as in abnormal disappearance or atrophy, warming procedures will be useful. After this general discourse, we will now occupy ourselves with the modus operandi and indications of the various individual forms of the compress.

Cephalic Compresses.

Method.—It ought to be really quite superfluous to go into the methods of applying cold and warmth to the head, since there is no resource more extensively made use of than the application of cold to the head, the patients mostly not waiting until the physician has given instructions, but, in the most various forms of headache, applying cold compresses without much consideration. It is true that physicians and the laity usually carry this out without any definite principle. Concerning cold compresses in general, that which Esmarch so properly remarked about them still holds good to-day: ‘Amongst all methods the most used, but still most improper and unsafe, is the application of cold compresses. It is possible therewith to call forth a constant abstraction of heat, but the contrary is brought about as often. If they are not frequently renewed, the inner surface of the wet compresses soon becomes of the same temperature as that of the inflamed part of the body; the radiation of heat therefore even ceases, and the

inflammatory elevation of temperature is increased instead of being diminished. At every renewal of the compress, an abstraction of heat again takes place for a moment; but the constant change of such very unlike impressions causes a constantly recurring irritation which certainly may act beneficially in some cases of sickness (Priessnitz's stimulating compresses), but very often increases the inflammatory action instead of diminishing it.'

It was imagined that all the disadvantages described so aptly by Esmarch as attending the cold compresses might be avoided by applying dry cold in the continuous form, bags being filled with water, ice, snow, or freezing mixtures. As a matter of fact where heat abstraction is alone required, and where it is anticipated that this must be continued for some time, so that one would be thrown upon the industry and goodwill of the nurse in applying cold compresses, it will usually be best to apply dry cold in any of the forms just mentioned, or to combine them with the moist compresses, which I much prefer.

For head compresses it will therefore be best that a cold compress should be first placed on the head, the best form being that of a cap consisting of two or three layers of linen; and in order to keep it cool for a long time or perfectly cold at will without having to change it often when it becomes heated more or less quickly, ice bags or bladders may be placed over the wet compress.

I, however, prefer the *cooling cap* for this purpose, an apparatus which I have had constructed for the continuous refrigeration of head compresses, and in which in addition the degree of this refrigeration may be fixed at will. Fig. 43 portrays this apparatus. At the head of the bed an arch is fastened, to which an indiarubber bag, in the form of a cap, is attached; by means of a conducting pipe connected with it, this cap may be filled with water of any temperature required, which is then carried off again by another tube; thus it is possible to send a continuous current of water through the indiarubber cap. When the bag is now brought into contact with the moist cap, the latter is kept constantly cool or cold at will without having to be changed. In this appliance the water bag, with its contents, does not rest upon the head of

the patient, since it is suspended from the arch; it simply refrigerates the compress without inconveniencing by its weight. But, apart from all this, the head can be cooled by this means



FIG. 43.—The cooling cap with running water.

with fresh water alone, and ice may be altogether dispensed with, as the fresh water rapidly running through the bag usually reduces the temperature of the head sufficiently.

The cooling cap for the head must be constructed in such a manner that the inner wall of the indiarubber bag is attached to the outer at numerous points, whereby the bulging of the inner side is prevented, and the object of the cooling cap is preserved, namely to make it lie evenly over the whole of the hairy convexity of the head.

A further advantage is to be gained by allowing the supply pipe to open into the lowest part of the cap, and the overflow to commence at the highest point, as thereby the whole cap is kept constantly filled with cold water as long as the supply is kept up.

I presume it must be *a priori* readily understood, that this

apparatus facilitates the process of applying cold to the head very greatly, that by its use the requirements demanded of the nursing department can be greatly reduced, and that the patient is much less inconvenienced when the compress need not be changed yet still remains cold. Just as little doubt, however, can remain on our minds that this is a superior mode of applying cold to the head to its application by means of the ice bag, when we remember that the latter lies only upon a circumscribed part of the head, and that the abstraction of heat becomes too intense in this part. The dry cold effect is besides much less intense, even though very low temperatures may have been used. Low temperatures, brought into contact with a dry skin, cause more powerful and permanent contraction of the vessels, and the skin, which has become a bad conductor through the greater part of its fluids having been expelled by the contraction of the blood vessels, must cause the refrigeration to be slower and more difficult to achieve.

My experience has indeed taught me that the application of dry cold is oftener followed by rheumatic affections than a corresponding application of wet cold. Particularly after the application of ice bags—and this all experienced physicians will corroborate—we not very seldom observe stubborn rheumatic pains left behind at the seat of their operation.

When therefore we wish to apply cooling compresses to the head, where the application is anticipated to be of considerable duration, and when we must endeavour to avoid every powerful reaction, then we will apply the cooling cap over the moist compress.

Modus operandi.—We intend to moderate the local temperature by the cold cephalic compresses, to influence innervation, to act anæsthetically, and to limit the circulation and local metabolism of the tissues.

The conditions for cooling and the deep penetration of cold seem to be more favourable in the head than in most other parts of the body. The bony skull is only covered by a very thin, easily refrigerated layer of soft parts; any considerable subcutaneous padding of fat is wanting, as is also a thick muscular layer, both of which are most calculated to retard the

conduction of heat. The most effective guard then against the penetration of cold or heat to the brain is offered by the hairs alone, and these are certainly easily enough removed, when it is considered necessary to do so. Yet the brain must be sufficiently protected against every considerable attack of temperature; this is indispensable to its function, and the necessary protection is furnished to the cerebrum by the great amount of blood, out of all proportion to it, with which it is flooded by every systole. It seems that the metabolic processes, so important to the function of the brain, must be made independent of external thermal influences, and this can only be attained by constant and regular irrigation with quantities of blood at the temperature of the heart. The rich blood supply paralyses the actions of cooling and heating upon the brain mass almost completely. This alone will explain how it is that patients can suffer the application of ice or freezing mixtures to the head for days and weeks without undergoing disturbances of cerebral function. This could not be possible if here the temperature were to fall ten or more degrees, as Esmarch has shown happens in the cavities of the bones of the extremities. Every actual reduction or elevation of the temperature of the brain itself would call forth serious disturbances of function, as the experiments of Richardson, in which refrigeration of certain portions of the brain called forth the severest sensible, sensory, and motor disturbances, go to prove. I think then I must adhere to the belief that thermal impressions upon the head, within the limits in which they can find application, will hardly call forth very profound alterations of temperature in the brain. The meninges appear to me to be less protected against alterations of temperature. Schüller's experiments have shown that the meningeal vessels contract and dilate upon stimulation by cold and heat. The thermal effects of heat supply and deprivation will here be not so much annulled by the circulation as seems to be the case in the brain substance itself. Heat and cold will therefore effectually alter the circulation and temperature of the meninges for us; we must then, as in the application of cold to any other portion of the brain, in applying cold to the head have regard to the reaction and the after effects. And herein again

lies a peculiar advantage which my cooling cap possesses over any other procedure, as it is possible by it to steal in and out as it were with the thermal stimulus and thereby avoid every more violent reaction. By cautiously stealing in and out with a low temperature we succeed in reducing the meningeal temperature and are able to keep it down as long as agreeable, thereby avoiding an undesirable reaction and possibly the return of the complaints.

Indications.—These may be deduced from what has been said already. A hot feeling in the head and most forms of headache, which may be set down as meningeal pains, may be modified or allayed by appropriate warm and cold applications.

If of a neuralgic character the pain will be allayed, as in superficial nerve tracks, by retardation or arrest of the conduction. Congestive and inflammatory meningeal affections will be delayed by cold or may be arrested completely.

Cold compresses further have the object of elevating the tonus of the cranial vessels, especially the meningeal, since the cerebral vessels themselves are hardly to be directly influenced thermally. Cold compresses to the head then will be suitable in all elevations of pressure in the vascular system, and where the consequences of such an elevation to the cranial vessels are to be anticipated; hence they will be useful in all congestive conditions and where there is danger of retro-stasial congestion.

Heating cephalic compresses will be more rarely made use of than the cold, and yet in certain processes a not unimportant *rôle* falls to their lot also.

Heating Cephalic Compresses.

Application.—The whole of the hairy part of the head, including the forehead, is wrapped up in a single or at most a double layer of thin, closely applied material, which has been wrung out in very cold water and is then covered by one or two layers of thick dry linen or woollen material. The whole dressing is applied after the manner of the capellene bandage or mitra capitis; it is generally applied in the evening before going to bed. Very rarely, and then only with great caution, do I allow such a dressing to be worn in the daytime, when moving about.

After the removal of such a vapour poultice the head is at once wrapped into a dry cloth, rubbed pretty thoroughly therewith and dried. It is better in many cases to rub the head with a damp cloth immediately after the removal of the dressing, and only after that to rub it dry.

Instead of damp cloths, warmed and dry ones will often have to be used when the compress does not sufficiently heat itself on a very cold head. In many cases it is useful, by previously tapping the head with the tips of the fingers and by gentle, dry friction of the head, to facilitate the subsequent warming of the vapour poultice.

Modus operandi.—The action of these water poultices rests upon a possibly rapid dilatation of the cranial vessels, which must be brought about by the thermal stimulation and prevention of the heat discharge by bad conductors, and sometimes by mechanical influence or direct heat supply. The latter can also be accomplished with the assistance of the already mentioned indiarubber cap, through which a stream of warm water is now conducted.

Indications for the use of these excitant cephalic compresses—which are still much too little availed of, even now—are provided by all forms of disease resting upon angiospastic processes—namely, headaches in anæmic conditions, many forms of spasm depending upon anæmia of the brain, many neuralgias and migraines of the head, rheumatic affections of the scalp, and chronic nasal catarrh with sparse and tough secretion. All these are frequently removed by the vascular relaxing action of the excitant compresses or by direct heat supply to the head.

Cervical Compresses.

These, like the cephalic, are also divided into refrigerating and heating compresses.

Method of Application.—The refrigerating compress must be kept continually cold, either by very frequent changing or by contact with a heat-abstracting medium. For this purpose the compress includes guttapercha tissue, and is covered with an ice bag or by an apparatus which I have devised for the special purpose, consisting of an indiarubber bag shaped like a collar which is either filled before applying to the neck with a freezing mixture, or through which

a stream of cold water is allowed to flow from an elevated reservoir, as slowly or rapidly as desirable. (See fig. 44.)

The ice bags are applied in such a manner that they extend from the mastoid process down to the clavicle on both sides of the neck.



Fig. 44. — Collar through which a stream of water may be sent.

Stimulating or heating cervical compresses consist in cold damp cloths, shaped like a cravat, which must be well covered with dry material. The compress may be either enclosed in impermeable coverings, e.g. guttapercha tissue, mackintosh or waxed cloth, or be simply covered with a dry woollen or linen cloth. The stimulating compress is to be renewed as a general rule, only when the moisture of the cloth has evaporated and it is nearly dry.

Modus operandi. — The cooling cervical compress causes a contraction of the large and small arterial blood vessels crossing the cervical region, and cools the tissues beneath. The effect, therefore, will not alone be a general one, but will extend itself also to the region of distribution of the vessels acted upon. A contraction of the carotids will diminish the blood supply to their whole region of distribution, to the formations within the pharynx and also to the head. I have been able to establish this directly by temperature measurements in the external auditory meatus and by measuring the heat discharge from the head and the face.

The local refrigerating action of the cervical compress upon the formations of the neck and the pharynx will only make itself felt under very energetic cold influence, by the use of very low temperatures, and under prolonged duration of the impression.

The *stimulating* compress, which is to call forth a dilatation of the cutaneous vessels, must become warm as rapidly as possible. The question has never yet been conclusively decided whether in covering the damp cold cloth lying directly upon

the neck with an impermeable material the action is more prompt and powerful than when the moist cloth is covered only simply, but thoroughly dry. In any case the compress which is covered with an impermeable layer must likewise be separately covered with a second cloth, since otherwise the greater radiation of heat and conduction by the guttapercha tissue or waxed cloth would annul the benefits of the arrested evaporation again. It seems as if the gradual drying of the compress without impermeable covering, whereby a fresh moistening is rendered necessary after some time, exerts a more powerful influence over the dilatation of the cutaneous vessels by repeating the cold stimulation than the other form of compress, which also often calls forth a peculiar uncomfortable feeling by preventing free cutaneous perspiration, and perhaps might excite a stimulating effect upon the vasoconstrictors by the retention of certain excretory products. In compresses covered impermeably, the hyperæmia of the skin becomes lost, and, furthermore, the heat discharge becomes smaller through greater maceration and soaking of the epidermis. Cutaneous eruptions also are more easily called forth by such compresses.

The *modus operandi* of the stimulating compresses has not been elucidated in all its parts as yet. The influence of the moist, nearly blood-warm vapour upon the tissues under the compress must here be certainly of importance.

Indications.—Cooling cervical compresses then will be indicated, on account of their local action, in *all inflammatory and irritative processes in the neck and pharynx*, the various forms of *angina*, *pharyngeal and laryngeal catarrh* and *inflammations* and, in their most energetic form, *in croup and diphtheria.* They will likewise find application in affections of the head, according to the principle which I have established, that in peripheral inflammatory processes the vascular and nervous regions by which conduction takes place should be kept as cool as possible.

The *stimulating* cervical compresses will find application in the later stages of catarrhal and inflammatory affections. In this case we will act derivatively to deeper-lying formations by the dilatation of the cutaneous vessels, and influence, by the permeability of the skin for the moist vapour, the processes of

diffusion, and promote resorption. The stimulating compress will also have a beneficial influence upon the secretion of diseased mucous membranes, dissolving it and rendering it more dilute.

We will here only cursorily remind ourselves that every refrigeration of peripheral strata of the body causes an elevation of temperature in deeper strata of tissues lying beneath them, which is a fact of importance to the indications for cooling and stimulating cervical compresses. In like manner, a warming of peripheral strata, accompanied by vascular dilatation, is succeeded by a fall in temperature of the deeper strata. Therefore stimulant cervical compresses bring about a fall in the temperature of the inflamed parts in angina.

Thoracic Compresses or Crossed Bandages.

Method.—Thoracic compresses are applied in the form of a woman's triangular shawl. A compress or napkin is folded diagonally, wrung out well in cold water, and then laid, with the point of the cloth upon the back, in such a manner that both ends can be carried over the shoulders and crossed over the chest like a comforter. The point of the triangular cloth may also be laid on the chest and the ends carried over the shoulders and crossed over the back. Both ends are drawn back and spread out over the sides of the thorax; or a square compress may be laid right across the anterior wall of the thorax and brought over the sides.

All these compresses, with the exception of the first-named form, can be renewed without necessitating the patient's moving. They may be used as cooling applications either by renewing them as often as required, or by keeping them constantly cool by contact with ice bags or cooling cushions.

For applying the stimulant thoracic compress (the crossed bandage) two ordinary abdominal bandages are necessary (Priessnitz's bandages). Each of them must have a length of 2 to $2\frac{1}{2}$ metres by 16 to 20 centimetres' breadth. The bandages, one of which ought to be supplied with narrow tapes which must go $1\frac{1}{2}$ time round the thorax, are now rolled up. The one without tapes is well wrung out in cold water, and is passed in the following manner round the chest: beginning at the left axilla it is carried diagonally over to the right shoulder, reversed and brought back again to the left axilla

over the back. It is then carried right across the chest to the right axilla, and thence upwards to the left shoulder, to be again reversed and brought back to the starting point until the end is reached, covering as much of the chest as possible. The second (dry) bandage is applied in an analogous manner, taking care, however, that the first one is everywhere covered, and the whole dressing is secured by means of the tapes attached to the final turn.

Modus operandi.—*Refrigerating thoracic compresses* are applied when we desire to operate antiphlogistically and anticongestively upon the organs in the thorax through the circulation and temperature. Schlikoff's and my experiments have shown that in ten minutes after the commencement of a cold impression over the surface of the chest an influence can be gained over the temperature of its cavity.

Influence over the vasoconstrictors seems also attainable through the sensory cutaneous nerves at the moment of contact, and this action may be explained as a reflex action through the sensory cutaneous nerves.

Indications.—We will therefore apply the refrigerating thoracic compress in inflammations and irritation of the pleura, in pleuritic pains, hyperæmia of the lungs and hæmorrhage most particularly, especially in the early stages of such affections. Most suitable for allaying pain, even for pleuritic pains, are the moist vapour dressings, in the form of the crossed bandage for instance, over which at the seat of the pain an ice bag is laid. Such dressings have not the disadvantages of local dry cold applications, which, as we pointed out previously, often call forth rheumatic pains in the parts over which they are placed or in their immediate neighbourhood.

The moist, blood-warm vapour dressing causes a cutaneous fluxion, and thus prevents the local vascular spasm caused by dry cold, which represents the disposition to rheumatism. The local anæsthetic effect of the cold is also greatly promoted thereby.

In active pulmonary hæmorrhage, the local and energetic application of cold in the form of refrigerating thoracic compresses, also finds an indication. In this case it seems particularly to be the cooling of the supraclavicular fossæ which is of importance ; it may be perhaps that here a great number of

nerve fibres is encountered by the cold stimulant, through the medium of which reflexes might be released, which conduct stimulating impulses to the vasomotors of the pulmonary arteries. Perhaps the efficiency of cooling the upper circumference of the thorax may be also explained by the heat abstraction reaching the apices of the lungs so very easily; and since these are so frequently the site of the hæmorrhage, the cold may perhaps act directly styptic to the injured vessels. Small ice bags over the supraclavicular fossæ in contact with a moist thoracic compress, seem to me to be the very best form of the direct application of cold in hæmoptysis.

Great irritability of the heart too, and very active and accelerated cardiac action and weakness of the heart, are often moderated or altogether removed by refrigerating compresses over the anterior surface of the chest and the cardiac region.

The mode of action of the stimulating chest compresses is still less explained even than that of the refrigerating.

Modus operandi.—The stimulating thoracic compress causes, by its low temperature, a very transitory stimulation to the sensory cutaneous nerves of the thorax, and causes deep inspirations to be taken at the moment of application. The compress soon becomes heated, at first to the temperature of the skin, and after some time, by preventing the heat discharge, nearly to that of the blood. The water contained in the compress evaporates, and the thorax is thereby placed in a blood-warm vapour bath, which dilates the cutaneous vessels of the thorax and must accelerate the circulation within them.

Very likely the modus operandi of the stimulating thoracic compresses depends partly, as Lauder Brunton supposes, upon the dilatation of the vessels, which, as by an irritant, is caused by the blood-warm vapour, and the liberation of the circulation at the seat of the application, which brings about simultaneously a contraction of the vessels of other internal parts of the body corresponding to the particular cutaneous region. By soaking the cutaneous nerves in the moist-warm vapour a perceptible beneficial influence is also exerted, very likely by reflex upon the bronchial nerves and the respiratory mucous membrane. The irritation of coughing is allayed, respiratory afflictions are modified, the bronchial secretion is diluted, and expectoration there-

by facilitated. Just as the longuettes act upon superficial and subcutaneous processes so do the stimulating thoracic compresses act upon the nutritive processes in the thoracic organs. Under the use of these dressings one often sees dissolution and absorption of old and hardened exudations, improvement, and removal of old catarrhs, and solution and absorption of the products of acute and chronic inflammations. The nutritive process and cell life must be here quite peculiarly well influenced under the moist blood-warm fomentation, in a manner hitherto unexplained.

Important for the explanation of the modus operandi of stimulating thoracic compresses seems to me to be also their influence over the respiratory function of the skin, which has hitherto been insufficiently investigated. Röhrig has shown that the skin is not impermeable to gaseous substances in the direction from without inwards. The moist vapour which penetrates the organs and diseased tissues in conjunction with the higher temperature in which the thorax is placed by the heated crossed bandage, seems to operate beneficially upon the processes of diffusion and circulation in the diseased organs. Vascular dilatation and acceleration of the circulation in the yet passable tracts of the lungs may be the results thereof. The moist vapour and higher temperature bring about conditions which must influence the organic processes in a manner similar to that of a hot-house. The moist, blood-warm, intimate atmosphere, which is kept up for hours, days, or weeks over the surface of the diseased thoracic organs, exercises this beneficial action.

Accordingly we may expect analogous topical actions from the crossed bandage, perhaps even more powerful ones, to those which Mittermaier and Rohden claim for climatic cures: 'The cheesy deposits soften up to the line of demarcation, and are expectorated, so that it is often possible to ascertain the existence of cavities tending towards cicatrisation which secrete a little pure pus, assuming, of course, that nutrition has been in the meantime improving. This method of causing the cheesy deposits to be expectorated seems to me, says Rohden, to be the most commendable by far, and, carried out judiciously, the least dangerous. For there is in this case no other kind of

cure than by softening, ulceration, and the formation of cicatrices; and as the presence of caseated products furnishes the important moment, out of which springs miliary tuberculosis, which has hitherto defied every therapeusis, we are in duty bound to labour for the elimination of these dangerous deposits.'

In cases, therefore, where inflammatory pulmonary processes exist, and the infiltration shows a tendency towards caseation or organisation, the products may become completely absorbed by means of the conditions induced by the moist vapour.

It appears to me that the character of these processes lies chiefly in anæmia, and particularly in local anæmia, since in one case the process itself causes circulatory obstructions, in another the local anæmia is increased through weakness of the circulatory centre caused by the general disturbance of nutrition. The conditions under which such processes may be cured can consist only in a lively promotion of the supply of fluids and in plentiful saturation with blood fluid, rapid in its circulation, and in the moist heat which favourably influences endosmosis, exosmosis, and cell life. But all these conditions seem to be attained by stimulating thoracic compresses. By copious irrigation with blood and fomentation with moist vapour, by local hot-house conditions established in the tissues an extensive necrobiosis can be fought against, and the conditions for the cure of such processes be brought about. If therefore, as I must confess, the theoretical explanation of the *modus operandi* of the stimulating thoracic compresses presents great gaps, practical experience has nevertheless sanctioned the powerful effectuality of this procedure in innumerable cases.

Indications for the stimulating thoracic compresses may then even at present be established simply by applying them to all those cases in which the most acute stage of the inflammation has subsided, and where the question of treatment resolves itself into causing the absorption or excretion of inflammatory products and allaying subjective affections dependent upon disease of the respiratory organs.

In all catarrhal affections of the respiratory organs, and in all inflammatory processes thereof—pleurisy, pneumonia—as well as in forms of disease developed from dyscrasic sources,

and in processes having a tendency to caseation and actually caseating or tuberculising, the stimulating thoracic compress will find rational indications for its use.

The Compress for the Trunk.

Method.—The compress for the trunk consists in a sheet which is folded three or four times lengthwise, according to the size of the body; and it must, when thus laid together, easily encompass the trunk one and a half time. Two sheets thus folded, one of which is wrung out well in very cold water, are then laid across the bed, the wet over the dry after the manner of a slip sheet, and upon them the patient is laid and wrapped up in the wet sheet, which should firmly encompass the whole of the trunk from the horizontal axillary line down to the symphysis pubis; the dry sheet is then rolled round the other in a similar manner.

The whole trunk, in other words nearly the half of the body, has now been enveloped in such a manner that the skin is directly covered by a layer of from four- to eight-fold wet, cold linen, which again is covered by a series of dry layers, more or less closely. A modification of this form of compress may be adopted in the case of patients who are absolutely not to be moved; it consists in passing only the dry sheet under the patient, whilst the wet one, which has to be folded correspondingly, is laid over the anterior and lateral surfaces of the trunk only. The dry sheet need then be only thrown back when the moist compress requires changing, a process during which the patient need not be moved in any way.

Modus operandi.—In addition to the influences previously described as exerted by compresses in general, there remains the effect upon the body temperature to be added in the case of the compress for the trunk. The equalisation of temperature which takes place in a comparatively short time, between the large cutaneous surface and the heat-abstracting medium, will be of influence upon the general heat of the blood and of the body.

The chief efficiency of the compress for the trunk, however, consists in the powerful direct and reflected nerve stimulation, the influence of which upon the muscular formations of the

abdominal organs, particularly the muscular vessels, is more easily explained since Stricker's discovery that in many places vasodilators run their course with sensory nerves. The stimulation of the vasoconstrictors over so large a surface of the body brings about the processes of blood stasis, collateral hyperæmia, and reactionary determination thereupon dependent. Another active factor of compresses for the trunk is to be sought in their influence over the alteration of the local temperature beneath the compress and in the abdominal cavity. We must deduce not less important effects from the moist, blood-warm vapour in which the greater part of the trunk, after the compress has become heated, may be kept voluntarily. The moist vapour acts by elevation of temperature and retention of water, on the circulation and the vegetative processes in the abdominal cavity. If we frequently renew the compresses for the trunk or keep them continually cool by suspending ice bags in contact with them, we will succeed in enforcing a refrigeration in the very depths of the organs.

Indications.—We will be able to apply truncal compresses, like every other form, as refrigerating and stimulating. Refrigerating truncal compresses, or such as are kept continuously cool by contact with an ice bag, or cooling bag with a current of water running through, will support the general heat-abstracting procedures as a means of reducing temperature in all febrile processes; they will, in fact, have even to be substituted for general heat abstraction in cases in which, on account of various circumstances, e.g. intestinal hæmorrhages, gastric ulcers, peritonitis, absolute immobility of the patient must be enforced. It is only when the cold compress projects a considerable extent beyond the limits of the diseased organ that this form of local heat abstraction becomes effectual in peritoneal exudations, gastric hæmorrhage, acute gastric and intestinal inflammations, as well as in extensive dysenteric processes. The circulatory processes in the abdominal cavity are also beneficially influenced by more or less frequent changing of the truncal compresses. In hyperæmia of the liver, congestive conditions in the organs of the pelvis, anomalies of menstruation and menstrual colic, the stimulating and refrigerating compresses to the trunk have often stood me in good stead.

The abdominal bandage follows the *modus operandi* of the truncal compresses, which, as we have seen, can only be applied whilst the patient rests in bed.

The Abdominal Bandage.

Method.—The abdominal bandage, or Neptune's girdle, also called the stimulating abdominal compress, consists in a piece of linen material, woven like a towel, which is from 40 to 50 cm. wide, and must reach two and a half or three times round the abdomen; it therefore will require to be of various lengths according to the circumference of the patient. A third of the bandage is immersed in very cold water and wrung out, rolled up beginning from the dry end, and then wound round the patient in such a manner that all the moist portion is in contact with the skin, and is well covered in by the dry two-thirds. By means of long tapes which are sewed on to the narrow end the bandage is retained in its position. It may be also covered with a flannel binder, or the last layer of the bandage may be lined with a piece of guttapercha tissue or mackintosh to prevent evaporation and to keep the compress moist.[1]

Modus operandi.—The sensory cutaneous nerves are stimulated by the low temperature, and all the more, namely, because the cutaneous regions involved in the cold stimulation—the back and the belly—are always kept warm, and are therefore much more sensitive to the action of low temperature than others.

Soon after the application of the wet bandage the temperature of the water in the linen and that of the neighbouring skin rapidly equalise themselves; the bandage becomes as warm as the skin, and, later on, blood warm on account of the bad con-

[1] This method, with the substitution of an ordinary sheet for the specially made towelling, is the one which is generally known as *the* wet pack in British practice, and to the best of my belief it enjoys a considerable reputation in the treatment of chronic abdominal affections, constipation, &c. According to Dr. Winternitz, however, this is an erroneous expression for the method, as it is and can only be a wet girdle, no matter how applied. Those, however, who wish to adhere to the term 'wet pack' on account of its expressing something which has achieved in their experience success in certain cases are quite justified in so doing, and even such a slight acknowledgment of the efficacy of a hydrotherapeutical measure may be taken as a symptom of something greater to be expected later on, whether the measure be used empirically (as it usually is) or not.—Translator.

ductors, the many layers of linen, or perhaps of the impermeable covering.

If the latter has not been added, the water evaporates pretty smartly through the linen coverings, and the bandage becomes dry; if, however, an impermeable layer has been added the watery vapour cannot evaporate, but remains in contact with the skin, and is cooled and condensed on the superficial radiating layers, thereby keeping the bandage moist.

The blood-warm watery vapour reacts upon the skin, and excites the peripheral cutaneous nerves, already made more excitable through the cold irritation. The warm vapour exercises a powerful, dilating stimulation upon the cutaneous vessels, the skin becomes more vascular, and the circulation is accelerated.

This circulatory acceleration in the skin is not without its effect upon the vascular conditions in the more deeply situated organs beneath the bandage; and it acts partly derivatively, partly by the moist vapour, which, as we know, penetrates the skin and subcutaneous cellular tissue, and perhaps has effect even at greater depths, exerting an influence over the nutritive processes in the abdominal organs. This would be the local action. But even the original nervous stimulus is conveyed to the central organs of the nervous system, viz. the brain, the spinal cord, and the medulla oblongata; the most important vital processes will be influenced by exaltation of innervation through various reflex pathways.

It often happens, however, that the abdominal bandage, in spite of the best dry or impermeable coverings, gets warm only slowly, and then even not very warm; it remains moist for many more hours, and causes a certain feeling of shivering. The reason for this phenomenon is the following: In a few patients who have worn the bandage for some months there appear, in consequence of an attack of indigestion, the symptoms of gastric catarrh, and the abdominal bandages which hitherto had always become warm easily, and were perfectly dry in a few hours, now remain moist for a considerable period, cause shivering, and may be found still damp in the morning, although allowed to remain on all night. The skin of the

part to which the application has been made remains anæmic and pale, and the abdominal bandage has no beneficial effect upon the gastric phenomena.

Clearly the cold stimulation of the bandage was too slight. The cutaneous stimulation operated, like too weak a one does on the sensibility to stimulation, as an excitant to contraction of the vessels only. A higher and more powerful cutaneous stimulation alone can call forth in such cases hyperstimulation or stimulation of the inhibitory nerves; therefore by causing a more powerful general thermal and mechanical excitation of the peripheral nerve endings to precede the application of the bandage, we shall obtain a complete reaction, and place the cutaneous nerves and vessels in such a state of excitement that the cold bandage rapidly becomes hot through dilatation of the cutaneous vessels and acceleration of the circulation in the skin; such measures would be: wet, cold shampooing, &c.

In irritable conditions of the abdominal organs, the stomach, or intestines a much higher degree of stimulation is required to set free the action of counterirritation, and to bring about revulsion by way of reflex. The contraction of the skin and its vessels, caused by the cold irritant, diminishes the vascular region of the skin and elevates the surrounding pressure and the tension in the vascular region of the internal organs. By the lessening in the amount of vascular space the obstructions to the circulation are increased, and, in consequence thereof, also the driving force of the heart. The result of this will be an acceleration of the circulation in the internal organs. When the bandage becomes warm a dilatation of the cutaneous vascular system takes place, and the blood is now driven with greater force into the dilated vessels, which contain little blood on account of the primary contraction; an alteration in the blood distribution takes place, and upon this depends the change in the activity of the organs. The function of the skin is stimulated, and the pathologically increased activity of the abdominal organs is moderated. The primary fluxionary retrostasis in the affected hyperæmic tracts is followed by a reactionary vascular contraction, which forces the blood out of these tracts and drives it towards dilated cutaneous vessels. Hyperæmia, congestions, catarrhal and

inflammatory phenomena, even in internal organs, may be improved or cured by this very simple procedure.

Indications.—The abdominal bandage then acts upon the innervation of the abdominal contents through alternating thermal reflex stimulation, also upon the blood distribution, the secretions, and organic heat; it will therefore hold its own in the treatment of most chronic or acute affections of the stomach and intestinal canal, the various forms of gastric catarrh and disturbance, circulatory disorders of the liver, particularly in passive hepatic hyperæmia, hyperæmia and stasis in the venous plexuses of the abdominal organs or hæmorrhoidal conditions; presupposing, of course, that it is applied in the orthodox manner, and changed appropriately at the proper time.

The Hæmorrhoidal Bandage.

Method.—A kind of T-bandage, whose vertical arm consists of an inner and an outer leaf, is applied in such a manner that the horizontal arm encompasses the body like a girdle, and is made fast, whilst the inner leaf of the vertical arm is moistened and covered by the outer, an impermeable layer being often interposed, then applied closely to the parts by drawing it tight between the thighs, and fastening it to the horizontal girdle by means of a safety pin.

The hæmorrhoidal bandage is usually only applied as an excitant compress in piles, inflammations round the anus, and eczema thereof, according to the principles laid down for all excitant compresses.

The Arm Bandage.

Method.—The name alone sufficiently implies the method of applying this compress.

Excitant compresses to the arm, consisting in a wet compress like a towel reaching round the arm one and a half time, and well covered by another, are sometimes usefully applied as derivatives in congestive conditions of the pelvic organs, profuse menstruation, and pollutions.

The Leg Bandages.

Method.—These consist in two pieces of towelling, each about a metre long, a third of each of which is well wrung out in very cold water, and then beginning at the ends, which are furnished with tapes, the bandages are rolled up, applied closely around both legs without creases, and secured in their place by means of the tapes. Both legs are thereby enveloped in a moist linen layer, extending twice round their periphery and covered by a dry layer which is about threefold.

Modus operandi.—Through the rapid heating of the moist part of this bandage up to the cutaneous temperature, and the threefold dry layer, which prevents the superficial escape of the heat, the bandage is soon warmed nearly to the temperature of the blood. This effect may be further enhanced by covering the whole dressing with guttapercha tissue.

The moist, blood warm vapour causes a dilatation of the superficial vessels, an increased capacity of the vascular space, and an acceleration of the blood-stream; hereby a constriction of the vessels in another vascular province is brought about, as the increase in calibre and acceleration of the blood-stream in the leg must be compensated by diminution in the capacity of another vascular province.

Indications.—The leg bandages are applied with the greatest benefit in congestions to the head, headache, and in all those cases in which we endeavour to diminish the amount of blood in the head and to derive blood therefrom. One or two pairs of wet stockings may be put on instead of the leg bandage, and covered in with dry material, or, when more powerful derivation is indicated, the whole of the lower extremities may be enveloped in corresponding dressings.

A form of dressing which allows of the attainment of warming and refrigerating actions, fulfils many another indication, and has assisted me in obtaining very numerous, favourable results in treating internal, and more especially external affections, is that form of dressing to which I have given the name of

Dressing à la Longuette.

Method.—Strips of various breadths of rather fine, used linen, or even of cotton, are prepared and then rolled up like rollers; they are

then immersed in cold water, moderately pressed out, and can be applied to any part of the body desired by simply unrolling them one over the other. With this material a dressing can be adapted to any part of the body, no matter of what form, which, without forming creases, will lie closely everywhere, and is held quite securely in its place by the adhesion of the wet strips to the surface of the body and amongst themselves. Such a dressing consisting of a varied number of layers, may now remain uncovered, and be kept cool or cold as desired, either by continuous or interrupted irrigation, or it may be also covered either with flannel, cotton wool, or gutta-percha tissue, so as to act when required as a so-called excitant or vapour poultice, and to furnish all the advantages and benefits to be derived from an occlusive dressing.[1]

Modus operandi.—In addition to the thermal factor, which here will also operate somewhat differently from other dressings, the mechanical factor is here most particularly important.

The refrigeration of a part under a longuette dressing will be much more regular, inasmuch as the part must not be uncovered nor exposed to the changing influence of the variously tempered air and the dressing. The dressing *à la longuette*, when it is not drily covered, remains cool for a long time in consequence of the evaporation of the water contained in the linen strips in a thin layer, and cools the parts it rests upon. If the precaution has been taken to spread a mackintosh under the part which is dressed, the dressing can be thereby kept moist and cool without having to be opened or having to touch and move the diseased part, or in any way mechanically irritating it. The fine, wet strips furnish the surface of the body with a casing, a guard which is of the most beneficial significance in injuries, wounds, and ulcerative processes, as it causes the rapid subsidence of pain and favours the cure.

Even in profuse suppuration I leave the last strips, or those in immediate contact with the ulceration, *in situ*, removing them only seldom, as it is mostly quite possible to wash away the secretions of the wound by prolonged irrigation with lukewarm water over the linen. The greater part of

[1] There does not seem to be any material difference between the author's dressing and the many-tailed bandage or bandage of Scultetus, beyond the preparation of the strips.—TRANSLATOR.

the secretions is washed away through the linen; the wound is not directly exposed to the air, and is also not directly irritated by the stream of water or other manipulations.

Besides this the dressing may perhaps also act by the gentle, equal compression, and when dry-covered, by the moist soaking.

Few methods in therapeutics that I know of are capable of bringing about a more rapid and favourable change in unclean wounds and ulcerations, atonic processes, and callous, solid exudations which resist most absorptive measures, than appropriate dressings *à la longuette.*

Therefrom the *indications* for this mode of applying water to the cure of disease may be easily gathered, I presume; and I have for years recommended its trial in obstinate ulcers of the foot, callous fistulæ, scrofulous groups of glands, burns, &c., all the more warmly because the powerful effects of the moist vapour, and the consequent soaking of the part, are in such superficial processes demonstrable *ad oculos*, and would be certain to materially strengthen confidence in the whole method.

Indeed, in the following section we shall have to recur once more to this dressing, which shares so many an advantage of the treatment of wounds at present in vogue and may be carried out with incomparable simplicity and cheapness.

Chapman's Spinal Bags.

The application of cold and heat to the spinal column is often resorted to, and the most convenient, albeit not the most effectual, means of application is offered in the various forms of ice bags or spinal bags of indiarubber, the type of which is known as 'Chapman's ice bag,' after its inventor.

Method.—Chapman's bags are made of indiarubber, of different lengths but narrow, and are laid either along the whole of the spinal column or only a part of it, being filled with ice or water of various temperatures. Each bag has some apparatus for securing the mouth, either a cork, a cock, or a screw and is furnished with slings or bands which serve to fasten it over the spine. But 'Chapman's ice bags' can be obtained anywhere almost, as they are very well known.

Modus operandi.—At best we are only incompletely in-

formed as to the action of different temperatures when applied to various parts of the spinal column. Chapman's own theory that, through the instrumentality of cold, a promotion and acceleration of the circulation was called forth in the parts of the body dependent upon the nervous central organs involved, whereas heat was to act by weakening the circulation, is just as little satisfactory as it is unsupported by sufficient and reliable experiment.

If the circulation in some parts of the body is to be stimulated according to this theory, *cold must be applied to that part of the spinal column in which the nervous centre for the particular part is supposed to be located.* Heat, according to the same author, will weaken the impulses of innervation emanating from the spinal cord; when, therefore, it is applied to the same part of the spine as cold, it will produce opposite effects to the latter.

Although many facts appear to support this theory, e.g. the experience that cold applied along the lumbar portion of the spine causes intense warmth in the extremities, and is often found serviceable in amenorrhœa and scanty menstruation, whilst warmth applied in the same situation improves or cures menorrhagia and metrorrhagia, there are yet numerous cases in which, having proceeded in exact accordance with this theory, we obtain either no result or an opposite one.

Therapeutical experiments the results of which still do not harmonise with our theory are herein mostly concerned.

Many a failure indeed may be attributed to the inferiority of the method itself; the Chapman's bags, namely, and most similar appliances as well, retain the temperature it is intended to apply for much too short a period, as the small quantity of the vehicle, be it ice or water, which the bag contains equalises its temperature with that of the body far too rapidly.

The thermal stimulus is hence in the ordinary apparata only very passive, the local refrigeration is too insignificant, and the renewed filling and readjustment of the bag much too troublesome and complicated, wherefore the method is mostly abandoned too soon when it might still often have operated favourably if carried out more circumstantially.

I am therefore fond of using, and, as I may assert, with great benefit, *dorsal compresses*, which may be kept either constantly or as long as desirable at the required temperature by means of a current of cold or hot water which is allowed to run through cooling cushions placed over them.

My interference, therefore, was often attended by success even after the ordinary Chapman's bags had been long applied ineffectually.

Indications.—At the present day, the indications for thermally influencing either the whole or certain parts of the spinal column cannot be established with scientific exactitude. The region of applicability of this form might however be a very extended one, as innervation and circulation can be effectually altered through its instrumentality.

In addition to the general pathological laws relating to cases suitable for cooling or warming the spinal column, and besides the previously cited examples of alteration of the circulation by means of the applications in question, I have learnt to recognise effectual refrigeration of the spinal column by means of cooling cushions, as a method *which is suitable to quite a surprising extent for reducing the exalted reflex excitability of the cord.* In numerous forms of spasms, chorea, and similar ailments this measure has often brilliantly succeeded in my hands.

Here also there is still a wide field to reward clinical and experimental research.

The Refrigerating Sound (Psychrophore).

Amongst the group of cold applications owing their effect to the elevation of tonus in certain groups of muscles I must also make mention of the refrigerating sound (fig. 45) which has been constructed according to my directions.

Description.—The refrigerating sound is a double-current catheter without an eye; the upper supplying canal ends near the point of the instrument, and the water flowing in is here taken up by the discharge tube and carried off. If now a piece of indiarubber tubing is connected with the supply

tube, and this in turn is connected with an elevated reservoir of water, whilst another tube is attached to the discharge pipe and conducted into a basin, on opening a cock which is attached to the supply pipe a stream of water of any required temperature circulates through the instrument, and constantly interchanges its temperature with that of the latter, and thus keeps it permanently cool according to the temperature which may be selected.

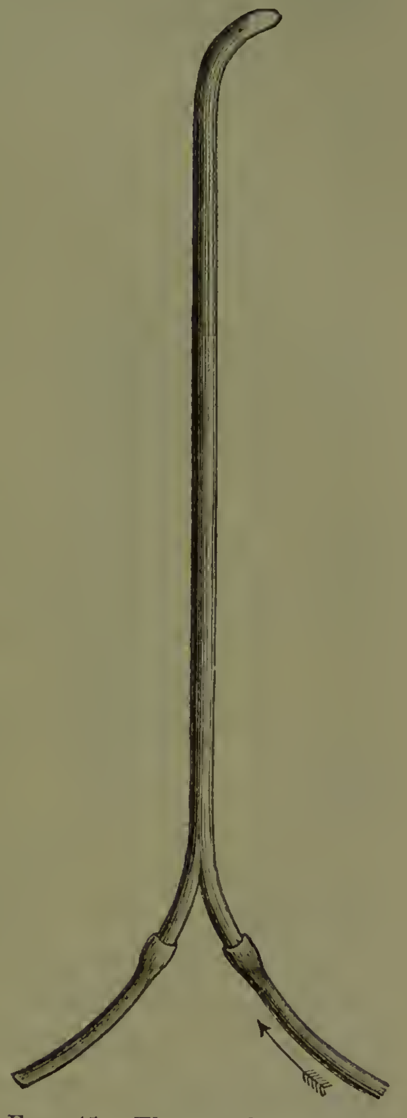


Fig. 45.—The psychrophore, a refrigerating sound for the urethra.

Modus operandi.—'Amongst the patients suffering from pollutions, spermatorrhœa, many forms of impotency, precipitate ejaculation, incontinence of urine, chronic gonorrhœa, and allied conditions there is a great number in whom a relaxation of the tissues and muscles predominates. A relaxed scrotum, softened testicles, a shrivelled penis, general laxity of the muscular formations, weakness and insufficient contraction, particularly of those muscles which govern ejaculation, incomplete erections, discharge of semen on moderate exercise of the abdominal muscles in defæcation, or of the bladder in urination, delay in the voidance of the urine, and dribbling thereafter are the symptoms of the more pronounced forms of this description.'

The anatomical substratum for such affections is a lowering of the tension of all muscles coming into play in these cases. The small sphincter muscles placed around the openings of the ejaculatory ducts in the urethra, the muscles governing the act of ejaculation, bulbo- and ischio-cavernosus, the fibres extending from the base of the bladder over the seminal vesicles, the sphincter vesicæ, and numerous contractile fibres embedded in and around the mucous membrane are those in question.

The principle for the *modus operandi* of the psychrophore is based upon the fact that cold stimulation powerfully elevates the tension of the smooth and striated muscles which are directly encountered by it.

This thermal gymnastic of certain muscles elevates, in a manner similar to mechanical gymnastics, the nutrition and capabilities of the muscle.

When now the refrigerating sound lies in the urethra in such a manner that its point has passed the membranous and prostatic portion, and extends to the neck of the bladder, all those parts upon which we desire to operate, namely, the whole of the very nervous and vascular urethral mucous membrane, the caput gallinaginis with its annular muscles, the sphincter vesicæ, and the muscles governing ejaculation, are subjected to the mechanical influence of the pressure and the thermal one of the low temperature.

In the most cases of abnormally frequent nocturnal emissions the pollutions become much more rare under the influence of the refrigerating sound. In treating these, three things have to be particularly regarded—

1. That the instrument introduced into the urethra be as large a one as possible.

2. That the temperature of the water used be not too low, water at 14° to 12°, or at the very least 10° C., being usually sufficient.

3. The duration of the application must be limited to eight minutes, and at the very outside to twelve.

Whether a favourable result may be looked for can usually be recognised on the withdrawal of the sound; if the urethra, namely, be tightly contracted around the instrument, so that a certain amount of resistance has to be overcome before it can be drawn out, it may be assumed that all the contractile formations have been placed in a condition of increased tension. Often, however, when the refrigeration has been too long continued and the water has been too cold, this favourable phenomenon does not take place.

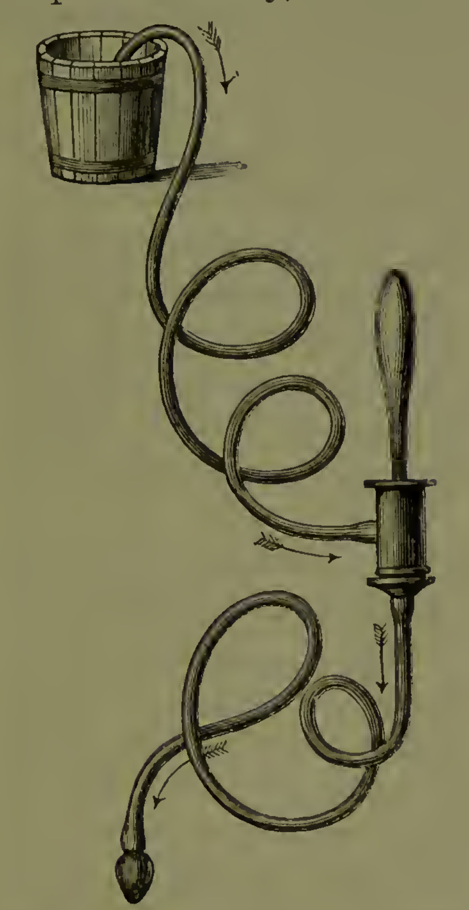
I have frequently observed cures, or at least decided improvement, to result from a methodical but not too frequently repeated application of this treatment to the forms of disease

just mentioned. I have also seen reflex neuroses, dependent on the genital organs, cured under the use of the psychrophore.

Based upon the same principle is

Atzperger's Cooling Apparatus.

This apparatus consists in a metal bougie, with a pear-shaped extremity, which is furnished with a supply and dis-



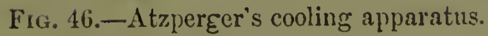


Fig. 46.—Atzperger's cooling apparatus.



Fig. 47.—Cooling bladder for the rectum and vagina.

charge pipe, connected by means of indiarubber tubing with a vessel standing on the floor. Fig. 46 represents this apparatus. When cold water is allowed to circulate through the tubes and the bougie, the latter is cooled and kept so; well oiled, it is introduced into the rectum and cools its entire neighbourhood. The vessels of the hæmorrhoidal plexus, the circulation in the prostate, the muscles of the sphincter ani, the numerous nervous formations of this region, the sphincter vesicæ directly, the muscular formations surrounding the outlets of the seminal ducts—all these are influenced by the apparatus in a manner

similar to the psychrophore. Its region of applicability embraces the passive collections of blood in the hæmorrhoidal plexus, piles, and their inflammations, and those of the surrounding tissues or periproctitis.

Under careful application of this apparatus a diminution, or even a complete retrogression of piles may not seldom be observed.

Having an action similar to this, but modifiable in numerous ways as well, is

The Cooling Bladder for the Rectum.

To allay a severe coccygodynia, I had an apparatus made which is based upon the same principle as the Atzperger, with this difference, that the action is to be mechanical by the equal compression exerted, as well as thermal by the temperature.

The cooling bladder (fig. 47) consists of a hollow metal bougie, from 6 to 12 cm. long, with a somewhat thicker and rounded off extremity.[1]

This hollow bougie begins after the manner of a double current catheter with two legs; a series of openings are placed round its narrowed neck whilst it ends in another series of openings, and the other leg communicates with two openings which are situated near the base and lower third of the bougie. At the point where the legs become united to the bougie there is a metal disc, the circumference of which is hollowed out for the reception of the neck of a thin indiarubber or fish bladder, which is here securely fastened watertight, having been first drawn over the whole bougie. Attached to the one leg of the tube with the pear-shaped extremity is a long indiarubber tube which is conducted to an elevated vessel of water, and the other leg is connected with a receiver on the floor by another piece of tubing, so that a stream of water sent into the bladder through the perforated tube will flow out again by the lower leg into the receiver. The bladder may be distended to any extent desired by compressing the discharging tube, and thus pre-

[1] Kisch has described a similar cooling apparatus for the vagina.

venting the water sent in from flowing off rapidly, the distension being proportionate to the degree of the hydraulic pressure and digital compression.

The apparatus is introduced into the rectum more or less deeply as required, the bladder having been well oiled and drawn tightly over the pear-shaped extremity, and the tap of the reservoir is then turned on. The degree of pressure to be combined with the refrigeration to which it is intended to subject the parts in question, is regulated, as before stated, by the compression between two fingers of the left hand of the discharging tube.

The bladder within the rectum, of course takes the shape of the cavity, and exercises an equal pressure on its walls. The refrigeration is intense and prompt, as the thin bladder in no way obstructs the interchange of temperature between the media in contact with each other.

The range of operation of this apparatus extends over hyperæmia and vascular dilatation, swelling and inflammation within the rectum, in the surrounding areolar tissue, in the organs of the pelvis, and to affections of the prostate. Cold impressions upon more deeply situated organs may be produced with as much intensity as in those placed superficially.

Metrorrhagia may be checked in a manner similar to the action of the vaginal douche by the application of the cooling bladder.

The apparatus may also be used as a vehicle for the supply of local heat by placing warm instead of cold water in the reservoir. Filled with warm water at 36° to 38° C., the bladder is of the greatest possible service in chronic inflammation, swelling and infiltration of the prostate, as well as the formation of abscess therein, and when a more prompt resolution of solid exudations, absorption, or acceleration of suppuration is desirable. More particularly, however, I have often had good results from the treatment of the painful tenesmus so frequently attending gonorrhœa, and of the strangury in acute vesical catarrh, by means of the rectal bladder filled with warm water.

Kemperdick's Refrigerating Sound.

Description.—This is an elastic œsophageal sound, which is perforated by an opening situated 30 cm. from the point, through which, and out of one of the two openings at the extremity of the sound, an English flexible catheter (No. 5) is passed, the points of entrance and exit being intimately secured round the catheter. A piece of bullock's intestine, 12 cm. long and about 5 cm. in diameter, is tied over the other end of the sound, which is then connected by means of indiarubber tubing with an irrigator containing 5 litres of water suspended from the wall beside the bed, and by means of another piece of tubing the end of the catheter within the sound is connected with a receiver standing on the floor. Having been well oiled, this refrigerating apparatus is introduced into the rectum from 20 to 25 cm. high up, and a stream of water allowed to flow through.

Modus operandi.—Through Kemperdick's sound an anti-pyretic action is brought about in the lower portion of the abdomen by direct refrigeration of the blood mass. Experiments on typhoid patients having a temperature of 40° C. in the axilla, showed that during the application the temperature rose to 40·8° after ten minutes, but after twenty minutes more it fell to 40°, and after removal of the apparatus to 39·2° within two hours. The temperature of the water on entering the rectum was 12° R. (59° F.); on leaving, it was 18° R. (73° F.) The application took place every evening when the temperature was at its highest, and the latter sank during the application by 1·8° C.; after removal of the apparatus it fell by more than another degree, so that the effect of the refrigeration in toto amounted to more than 3°. The application is easy, and is borne without suffering of any kind.

The Enemata.

Administration.—It will be hardly necessary to describe in detail the various apparatuses which are used in administering enemata, since they all are based either upon the principle of the simple syringe, the force pump, or the irrigatory appliances. The simplest and best appliance is that so well

known as Hegar's funnel, or an irrigatory can, which may be elevated or lowered at will, and is furnished with a long tube, the height of the column of water representing the mechanical force by which the fluid is impelled into the intestine under constant pressure. In adopting this appliance the driving in of air is avoided, and the water is infused with a force which can be graduated. It is better to have a long tube for introduction into the intestine, as by a shorter tube the fluid is only injected into the lowest part of the rectum, in about the situation between the internal and the external sphincters, which region would be immoderately distended by a large quantity of water. For the same reason the French irrigatory apparata, in which the water is driven in with great force by the pressure of a spring, are also inappropriate, as the sudden distension of the intestine is connected with numerous drawbacks.

Modus operandi.—In this case also the mode of action comprises a mechanical and a thermal factor. By reason of the mass of water which fills and distends the intestinal tube, the muscles of the tube are stimulated to contraction. Enemata, therefore, whose action is evacuating, act chiefly by their bulk, as the intestine reacts against the injected fluid as against a foreign body.

The temperature of the injected fluid will either support or check the mechanical action. We know from physiological experiments that cold stimulates peristaltic action, whilst heat retards it. Cool and cold water injected into the intestine powerfully excites peristaltic motions: this is made manifest by a discharge of gases from above and below. It is often quite possible when the abdominal parietes are thin to recognise plainly the most lively peristaltic movements, as well in the stomach as in the small and large intestine, both by sight and touch. This accelerated peristalsis conveys the contents of the gut more rapidly towards the lower outlet of the intestinal tract.

But in yet another direction, cold water injections by the rectum seem to conquer torpor of the intestine, and to prove useful against habitual constipation, which may be explained by their influence upon the circulation in the vessels of the stomach and intestine. The rapidity of the current in the

portal vein seems to be increased by the muscular contractions of the gut, hence the secretory pressure must also be increased for the secretion of the bile. Röhrig has proved that watery injections into the intestine increase the secretion of bile for a time. An increased secretion of the bile, however, always causes a more lively peristaltic motion.

Tepid water also seems under circumstances to find indications for its use in habitual constipation, and it is especially the irrigation of large quantities of fluid which is effectual, probably because it alters the condition of the contents of the large intestine by softening and dissolving them. The contents of the gut thus altered are more easily expelled, although the higher temperature would rather slow than accelerate the peristaltic action. The mechanical factor here is operative in the same manner as in the injection of cold fluids.

But, on the other hand, we can effectually alter the temperature of the body by the introduction of warm and cold fluids, which is yet a further factor in the modus operandi of injections into the intestinal canal. The application of clysters in febrile diseases was resorted to even in the oldest times; but it is only recently that they have been subjected to a methodical trial for the purpose of ascertaining their utility. By administering enemata *coup sur coup* Foltz endeavoured to reduce the temperature in typhoid fever, an attempt which succeeded in so far that by means of injections administered from every two to four hours, the febrile temperature was reduced by one degree. I myself have observed the temperature in the stomach to fall by 0·9° C. on the injection of cold water into the rectum. Since we are in a position to cause reduction of temperature in such distant organs as the stomach and even in the whole body by means of cold clysters, how much the more will we be able to influence, as we desire, the immediately neighbouring organs of the rectum and large intestine in their temperature, and thereby in their processes of nutrition? The absorption of fluids introduced into the rectum may also here and there find therapeutical application.

Indications.—Injections, enemata, or clysters are then indicated as measures to promote evacuation. Up to a certain degree it is quite true that enemata given without the neces-

sary technical knowledge or caution soon become ineffectual, and that one soon gets habituated to their use, aye, even that the torpor of the bowels is at last still further increased by this procedure. This depends entirely upon the method by which enemata are administered, a sudden distension of the lowest part of the bowel being capable of causing after a time atony of the muscular coat, and hence increased difficulty in defæcation. The application of *lavements* at every stool or desire to go to stool finally incapacitates man for a natural, powerful exercise of the abdominal muscles. The muscles thus placed out of work become weaker, and in this way the enema, which at first stimulated the evacuations only thermally and mechanically, may ultimately lead to obstinate habitual constipation by weakening the abdominal muscles. Warm fluids also can become deleterious by their action upon the contractile powers of the muscles which they relax, and by their lowering effect upon the innervation. Low-tempered fluids injected in very small quantities into the lowest part of the bowel, or infused gradually into the upper portion of the large intestine by means of a long tube, do not easily lose their efficacy, and will prove useful even after years of constant use.

I need not here give more detailed indications concerning the worth of irrigations of the bowel, since various clinicians have recently made themselves thoroughly acquainted with this subject. I will here only speak of their powerful effectuality in disturbances of digestion, chronic gastric catarrh, hyperæmia of the liver, and jaundice. Following the recommendation of Krüll to carry out methodical irrigations of the bowel twice or even thrice daily, with 1 to 2 litres of water at 18° to 20° C., I have achieved some success in the treatment of icterus more particularly. Usually a general feeling of comfort follows the irrigation; the depression disappears, as does also the itchiness, and the tension in the hepatic region and the constipation are, at first passively, but soon after permanently, suspended together with the yellow tinge. Acceleration of the peristalsis, of the current of blood in the portal vein, the promotion of the secretion and excretion of bile, and perhaps also the influence of the absorption of water by the bowel, seem to be the effective factors which cause the disappearance of gastric and intestinal phenomena and icterus more rapidly than usual.

FOURTH SECTION.

COMBINED HYDROTHERAPEUTICAL METHODS.

General.

Having examined and discussed the modus operandi of thermal and mechanical interference so far as it has been hitherto investigated, as well as the procedures constituting the method of cure by means of water and their special actions, we have now to take up a position on the question whether the so-called 'Water-cure' is entitled to the significance of a curative agent. When it is taken into consideration that the pathological occurrences in all organs and systems of organs may be attributed to a comparatively small number of processes, and that most of these may be influenced by means of thermal, mechanical, or combined interference in a manner which can be previously calculated on, it will be hard to deny to such a conscious and often most successful treatment the significance of a rational method of cure. We underrate the value of hydropathy when we rank it with a simple drug.

By the aid of certain thermal and mechanical procedures, we are able to fulfil indications established symptomatically, to remove certain disturbances of nutrition, to influence innervation here and alter the circulation there, to stimulate or arrest certain secretions and excretions, to control the heat processes in the organism, to influence metabolism in various directions, and to do much besides. By a suitable methodical combination of all these individual actions, we obtain numerous methods which are capable of removing even more complicated disturbances of nutrition. These interferences when combined, according to a plan based on rational

principles, convert the whole procedure into a scientific method of cure. Thermal and mechanical interference becomes operative through the alteration which it brings about in the organs, the organic systems, and their functions. The magnitude of the action, therefore, must depend, under otherwise equal conditions, upon the force of the impression and the sensibility of the individual attacked, the varieties of which, as we know, are countless. Hence, it is impossible to establish definite procedures for definite effects, as is the case with every medicinal action. Quantity and often quality of the agent must here also be frequently modified, according to individuality and circumstances.

As we have already said, it is not possible to establish for hydriatic medication quite definite and unalterable forms and formulæ. For example, we cannot speak of absolutely excitant nor of absolutely palliative procedures.

This can occur all the less since a goodly proportion of hydriatic actions are not to be attributed to the primary effects of the interference, but to the *resistance* of the organism to the alteration primarily induced—the reaction. The magnitude of the reaction following a certain interference changes, however, according to the individual and circumstances, and is only partly dependent upon the mode of attack; this applies to every other curative method as well. A further superiority of this procedure consists in the circumstance that, up to a certain degree, we can yet regulate the reaction by our mode of action. The certainty of therapeutical operation would gain much had we a *measure for the irritability and style of reaction* of each individual under treatment. This question cannot be answered to-day; but we nevertheless possess some aids for the estimation of both properties, and the practical results to be deduced therefrom.

If after simply drawing the point of the finger over the skin, or cursorily touching a cutaneous spot with a cold, wet cloth, white traces remain behind the mechanical or thermal irritation, we may conclude that there is great excitability of the vascular nerves. On the other hand, it is observed in many individuals that prolonged vascular dilatation follows the mechanical irritation, so that one is able to write in plain, blood-

coloured outlines upon such a skin. The immediate significance of this consists only in a slight exhaustibility of vascular innervation, or perhaps greater excitability of the inhibitory nerves. I have met this peculiarity particularly often in so-called nervous and hysterical individuals.

If a cutaneous irritation so inconsiderable as this is followed by an alteration in the type of the respirations and frequency of the pulse or cardiac force, then this great irritability must be assumed to exist in the nervous central organs of the particular systems as well. An areolar cyanotic injection following passive impressions by cold, points to cardiac weakness, and is often the first sign of impending collapse.

Rewarming after heat abstraction (the reaction) also displays in different individuals the greatest variations, in which may be found many points for guidance and attack, useful as well to pathogeny as to prognosis and therapeutics.

It is of peculiar importance to the latter that we be in a position to control effectively the rewarming after reductions of temperature, its more rapid or gradual onset, and the degree of reactionary elevation of temperature. This rewarming—the most certain sign and most prominent symptom of reaction—which may be additionally recognised by alterations in innervation, the circulation and metabolism, depends, under otherwise equal conditions, upon—

1. The absolute amount of the heat abstraction. The greater, within fixed limits, the reduction of temperature, the greater will be also the reactionary elevation of temperature.

2. The more rapidly the abstraction of heat is carried out, the more rapidly does also the secondary rise of temperature follow.

3. The duration of the refrigeration is of influence upon the sooner or later following recovery of heat. Heat abstractions, longer in duration and more gradual, are followed by a slower and less intense elevation of temperature than short ones accomplished by means of lower-tempered water.

4. The height of the body temperature before the refrigeration, influences the reactionary temperature elevation; a body which was very warm previously reacts more powerfully than a colder one.

5. Heat supply prior to the application of cold elevates the

intensity of the reactionary processes, together with the irritability.

6. The combination of cold with a mechanical stimulus increases the reaction.

7. The behaviour after heat abstraction has also an influence upon the more or less prompt appearance of reaction, quiet bearing retarding, and work or muscular movements accelerating and increasing the reactionary processes.

8. The internal use of stimulants, particularly of alcohol, also promotes the reactionary processes after heat abstraction.

9. In general the reaction, as well as the heat production, stands in direct proportion to the thermal nerve stimulus; the more powerful the latter, the more powerful will be the former.

10. Excessive cooling down may lead to a late and excessive or incomplete reaction. Whereas the first may make itself manifest by conditions similar to fever, as well as by actual febrile conditions, incomplete reaction displays more the character of algidity and collapse.

It is a matter of course that in the treatment of more complex nutritive disturbances, as we shall presently evolve, we must keep these described reactionary laws constantly before our eyes. As a *sine quâ non* condition of every methodical water cure, it must always be observed that the individual procedure is followed by a complete reaction. It may have been desired in the plan of the cure that the reaction should come on only gradually and not become excessive; this applies especially to the treatment of febrile diseases. It may be further desirable to excite rapid and extensive reaction—this will be our endeavour in the generality of chronic nutritive disturbances and in all retardations of metabolism. Never, however, can we regard an incomplete reaction as desirable, since it is always accompanied by such pathological phenomena as nervous agitation, depression, paleness, small pulse, constant shivering, irregular heat distribution, and disturbances of numerous functions, and may even carry serious nutritive disturbances in its train.

By observing the above laws we can easily avoid these dangers. We must accurately observe the bearing both before and after the refrigeration, and even estimate the degree of the latter. An excessive reaction, as is often shown by

recurrent typical febrile disturbances and a retrograde tissue metamorphosis, is, in addition to excessive and careless heat abstractions, the consequence of the accumulated after-effects of prolonged and exhausting water cures. After a very cold bath taken during a normal condition of the body temperature, a period of inconsiderable elevation of that temperature may, at least for a short time, be observed. This is a compensatory phenomenon, following the reduction of temperature, which was described as the remote after-effect of heat abstraction. An accumulated after-effect such as this may be most clearly recognised after a series of heat abstractions, particularly when the individual baths followed each other in rapid succession before the phenomena of reaction had completely run their course, and finally, the after-effect may increase to the height of actual fever.

Metabolism during this time displays the characters of a febrile process—highly saturated urine containing much urea and uric acid, and loss of body-weight. A great tendency to sweating in addition to the subjective febrile symptoms—languor, depression, loss of appetite, constipation, &c.—occurs also. The empirics, to whom these phenomena were well known in consequence of their reckless cures, gave to them at one time the designation of *crises*, at another, *satiety through the water cure*. The accumulated after-effect of the baths may have a beneficial effect upon the nutritive disturbance by its influence over tissue metabolism and the secretions; it may, however, be also deleterious by the very same effect in certain individuals and processes. Both are comprehensible when we remember the alterations in metabolism under heat abstractions. We know that these exert a very different influence over tissue metabolism, for whilst thermal nerve stimulation causes principally a reflectorially increased disintegration in muscle, concerning chiefly non-nitrogenous materials, the secondary after-effect following heat abstraction carries with it an increase of albuminous decomposition.

True refrigeration of the tissues causes a retardation of the tissue consumption. All this we must keep in sight if we wish to make appropriate therapeutical use of the thermal and mechanical influences. I have not forgotten the

'CRISES'

of the hydropathists, and am now about to give my views concerning them.

To every unexpected phenomenon turning up during the use of the water cure, the empirics were wont to attach a critical significance. To this category belong all those external forms of eruption often appearing under the use of the water cure; further, various secretory processes coming under observation; and, lastly, the already mentioned conditions so resembling fever, which appear as the after-effects of refrigerations.

As regards the cutaneous eruptions, various forms of eruption occur which really owe their existence to the hydriatic procedures. The thermal and mechanical irritation of the skin may call forth many inflammatory processes in the skin which appear in the forms of *eczema*, *furuncles*, *erythema*, *and urticaria*. There are individuals presenting so great an irritability of their dermal organ that the result is the impossibility of carrying out the cure. Such an idiosyncrasy towards temperature and mechanical irritants belongs, however, to the greatest rarities. The most frequent eruptive forms appearing in consequence of the water cure are caused by vegetable parasites—by varieties of fungi. First of all, herpes tonsurans should here be made mention of; vapour poultices, which are often worn for weeks and months, are the hotbeds for these exanthematic forms. The most scrupulous cleanliness, frequent changing of the cloths used for the compresses and regularly repeated boiling thereof, inunction of the fomented skin with a pure, fatty substance, and frequently washing the skin with tepid water and an ordinary potash soap, are the most effectual means of protection against the appearance of these parasitic exanthemata. A critical significance of any kind in the same sense as the old humoral pathologists used it, may not therefore be attached to the bandage eruption, herpes tonsurans or eczema. These eruptions can only be accredited with the therapeutical advantage of causing intense and prolonged cutaneous irritation, which in itself is usually much more of a disadvantage; they often rob the patients of their night's rest,

make them very nervous, and lower them exceedingly. Hence it must rather be our endeavour to avoid their appearance than to promote it, as was formerly believed by a large community, and that not consisting of the laity alone.

Much the same may be said of the furuncles, phlegmons, and carbuncles, notwithstanding reliable experience has shown that many patients, after recovering from a whole series of such cutaneous glandular inflammations, have observed improvement in their various chronic affections.

Neither may these processes now be regarded as *critical* in the sense that by the determination, the suppuration and necrobiosis the expulsion of certain diseased materials had taken place.

But that the profuse sweatings which sometimes appear during water cures must be accepted as *depurative* and *blood cleansing* processes, and that certain specific odours adherent to them should betray their critical nature, has not been sufficiently investigated, or may not even be investigable, to enable us to pass a definite judgment in this respect upon their significance. Much the same holds good with regard to sudden alterations sometimes observed in the urine, and suddenly appearing diarrhœas; under circumstances they may, by their influence upon the whole of the tissue metabolism, prove themselves to be curative, but oftener also detrimental processes. A general rule cannot as yet be established in any way relative to this.

Very interesting are the sudden phenomena which sometimes appear after cold procedures, and which certainly are brought about by the thermal nerve irritation, such as *icterus*, *urticaria*, and *hæmoglobinuria*. The genesis of these processes is, however, as yet so dark that I shall rest satisfied with having made mention of them in this place.

We will now endeavour to show how, by a combination of different hydrotherapeutical procedures, we will be in a position to do battle with more complex disturbances of nutrition.

THE INFLUENCE OF HYDROTHERAPEUTICS UPON CIRCULATORY DISTURBANCES.

Hand in hand with nearly every disturbance of nutrition, we observe alterations in the circulation to take place. For this reason, and because the chief effectuality of hydrotherapeutics is to be sought in this direction, we will first of all occupy ourselves with its influence upon circulatory disturbances.

The most important normal functional processes, and the numerous pathological processes, are either accompanied by or dependent upon circulatory disturbances. Too great or too small a blood supply, too rapid or too slow a blood current, too high or too low tension in the vascular system, and too great or too slight blood pressure, are the conditions, or at least the accompaniments, of the most varied nutritive disturbances. The intimate metabolic changes in the tissues must necessarily also suffer alterations, in consequence of the anomalies in the circulation. The blood coursing too slowly or too rapidly through the tissues causes not alone changes in the temperature and the cooling and heating conditions, but certainly also alterations in the organic mechanism. Only under normal circulatory conditions is it possible for the blood and organs to maintain their normal composition and normal function. It is, therefore, one of the most important problems of therapeutics to bring anomalies of the circulation back to normal again, and thereby alone we will often have removed the intimate pathical processes lying at the root of the disease.

Having particular regard to the circulatory processes, the nutritive disturbances may be separated into two great groups, of which the one bears the character of active circulatory disturbances impressed upon it, whilst the other displays more the character of *passiveness, of arrest and weakening of the circulation.* The disturbances may in both cases be either only local or general. To the first group belong *local and general hyperæmia and accelerations of the circulation*, and elevations of pressure in the vascular system; in the second group *must be placed local and general anæmias, every kind of arrest,*

weakening and obstruction of the blood and lymph streams, as well as of the blood pressure, passive stases and similar processes. We shall commence our dissertation with the hydriatic treatment of the active circulatory disturbances, and first occupy ourselves with the

Hydrotherapeutics of Local Hyperæmia.

The treatment of this condition must be a very varied one, as will be easily understood, according as the local hyperæmia is only the expression of a local atony of the annular muscles of the hyperæmic vascular district, or when it owes its origin to an elevation of the vascular tonus of another district, and must therefore be considered as collateral hyperæmia. Lastly, the treatment will also be different when its object is to restore arterial resistance, the loss of which is based upon nervous influence. In the majority of pathological hyperæmias, in congestions, fluxions, and determinations, the therapeutics must be generally intended to act all in the directions indicated. We must therefore endeavour to place the relaxed circular muscles of the vessels into a condition of higher tension by means of thermal procedures, with whose assistance also we will strive to check the blood supply to the congested parts ; we must further seek to divert, thermally and mechanically, the current of blood towards that region of collateral anæmia which is constantly to be found in every extensive hyperæmia, and we must finally, by means of indirect excitation of the vasomotors of the hyperæmic part, endeavour to diminish the congestion. These general principles can, according to the locality of the affected part, only be carried out in very different ways; we shall therefore demonstrate by examples of one or the other how in every case the indications may be deduced and how we can fulfil them. The most noticeable and simplest example of the matter in question is furnished by a *local, external hyperæmia* and *fluxion*, which is best when *caused traumatically.* Let us then consider a local active hyperæmia, such as would be occasioned by a blow or a burn of the first degree, or by a chemical irritant, such as a sinapism or other rubefacient ; in this most simple case of relaxation of the circular muscular fibres of the vessels at the irritated part,

the local contractile stimulus of cold usually suffices for the obliteration of all diseased appearances. The pain, the vascular dilatation and increased blood supply, the accelerated circulation and elevation of temperature, all disappear regularly under the *sufficiently prolonged and regulated influence of cold; at the same time every mechanical irritation, the contact with different media, and exceedingly low temperatures must be avoided.*

From the experimental and theoretical representation of the action of thermal influences upon the vessels and nerves

The Anticongestive Hydriatic Method

may easily be deduced. Its rules are: the part attacked by the determination of blood and hyperæmia—and this applies just as well to the initial stages of inflammation—must be kept cool; this can in most cases be best accomplished by means of compresses dipped in water at 10° to 20° C. These compresses should be of such construction that they need not often be changed, yet still keep their regular low temperature. The rarity of change of the compresses over the suffering part is desirable, because at each change of the cloth, even under most careful manipulation, a mechanical irritation of the hyperæmic, inflamed, or injured part is unavoidable. The first indication, however, in all congestive and hyperæmic conditions consists, with a few exceptions which will presently be discussed, in bringing about the conditions necessary for the complete rest of the affected part. A further circumstance which renders the unfrequent changing of such compresses over the diseased part a desideratum, is the bad effect which would have to be feared from the influence of sharp variations of temperature upon the affected part. But as it is impossible to avoid that the strata of linen lying directly over the pathologically heated skin should get warm by interchange of temperature, if the changing of the compresses be ever so diligently carried out, every fresh one would bring the diseased part in contact with very different temperatures. No matter how frequent then the renewal of the compresses, it always consists in a varying impression by cold and heat, and in a constantly varying contact of the surface of the skin, now with air of a different temperature, now with wet

cloths of different temperatures. Such a continually altering thermal and mechanical irritation must surely be detrimental, particularly in inflammations and in wounds, as well as in hyperæmia. The rapid change of heat and cold elevates, as we are aware, the nerve irritability and excitability, and causes a to and fro movement of the blood in the diseased organ, so that we have now congestion from heat, now congestive retrostasis, now slowed or accelerated circulation. A factor, however, which is not sufficiently estimated is the alternating contact of the diseased part, now with air, now with water, both of which are media of different physical properties, which is unavoidable when the compresses are diligently changed. This alternating influence must above all others be kept down, as it will undoubtedly have an irritant action on the circulation in the parts involved. How then can we avoid the described disadvantages, and keep the affected part at a regular low temperature so long as it is intended to act *anticongestively*? and how prevent the contact with different media, and, by less frequently changing the compress, keep also the mechanical irritation in check?

This can only be attained by making use of the physical property which water possesses when in a thin layer, of evaporating rapidly, especially when constantly heated and thereby abstracting a great deal of heat from the opposing media. The water will be in the requisite, evenly distributed condition when a linen cloth, whose texture is rather fine, is wetted and wrung out moderately. If we now put on a dressing *à la longuette*, such as we described at p. 537, in a simple or at the outside a double layer over the hyperæmic or inflamed part—secundum artem and evenly—we have brought about all the conditions which we have just described as desirable for the removal of hyperæmia, congestion, and the initial stages of inflammation.

The local refrigeration becomes regular and constant by means of evaporation or by irrigating the dressing. Moistening, irrigating, or dropping water upon the dressing must take place without exposing the affected part to the irritation of the concussion or friction of the water mass. The force, therefore, with which the water encounters the dressing must be so slight that the cohesion of the linen can completely

annihilate the shock, and the water may distribute itself in the linen only according to the laws of capillary action over the part thus dressed.

Under this method of treatment sensations of heat and pain first of all disappear, because in addition to the reduction of temperature, the conductivity of the centripetal nerve endings is also lowered, and the vascular muscles are placed in a condition of elevated tonus. In yet another manner may the problem here given—namely, to cool directly, continuously and equally the congested and hyperæmic organs—be solved, and that is by placing an appropriate refrigerating apparatus in contact with the part which was covered either by wet compresses or the longuette dressing. The best apparata are the various cooling bladders with a current of water flowing through, which we have previously spoken of, and which render themselves especially useful by obviating the necessity for applying ice and perhaps too low degrees of cold, as well as the evil effects caused thereby. Besides this mode of combating hyperæmia, congestion, and the initial stages of inflammation in superficial and accessible organs and parts of the body, we can also diminish the blood supply to hyperæmic and inflamed parts more deeply situated, by yet another method. This is accomplished by means of thermal contractile stimuli, *which we apply along the course of the arteries and nerves supplying the region.* Compresses intended to effect contraction of the large vascular trunks conducting to the inflamed organs, or to be effectual by their action upon the nervous trunks containing the vasomotors, must be applied at very low temperatures. Hence we will apply ice poultices, and even artificial cooling mixtures centrally to the hyperæmic and inflamed organs; these, in the true sense of the word, *antiphlogistic compresses* must be kept constantly cold, whereas, as I explained before, the actually inflamed parts themselves need only be kept cool. For example, in inflammations around and in the head we must endeavour to cause a contraction of the carotids, and thereby a diminution of the blood supply to the head, by means of cold applications to the neck, stroking the carotid sulcus with pieces of ice, ice bags and the like, which we lay over these parts. In inflammations of the

upper extremity, we must envelop the whole arm up to the inflamed portion in snow or ice poultices, and in inflammations of the lower extremities apply similar agents to the thigh.

But in yet another and third manner will it be our endeavour to diminish the blood supply to congested, hyperæmic, parenchymatous organs which are not accessible to the direct influence of cold as just described; we accomplish this by way of *thermal reflex excitation* and by *direct derivation of blood.*

The first-mentioned mode of interference, also called *revulsive action*, is operative in that we apply cold to certain peripheral sensory nerve-endings which are known to stand in reflex relationship to the diseased parts. I have established a great number of such reflex points in practice. I will here only refer to the influence of *foot baths* on the temperature of the head. I will also remind the reader of the influence of *running hand baths* upon the circulatory conditions in the thoracic organs. There are also undoubtedly numerous *points in the spinal column* whence various circulatory regions could be thermally controlled; to these we referred when discussing Chapman's ice bags.

By means of the so-called *derivation of blood* we can gain influence over various hyperæmias and congestive conditions; it is carried out by dilating a large vascular district and drawing the blood to it from other organs, thereby also withdrawing it from the hyperæmic ones. The usual hydriatic region for derivation is the great and very vascular dermal organ, and when we remember that in a skin with very dilated vessels well-nigh two-thirds of the mean normal amount of blood can find room, we can comprehend that such a derivative district will alter the amount of blood and the circulatory conditions in other organs very powerfully. We discussed the means for causing hyperæmia and congestion of the dermal organ when speaking of the technique. *Friction, wet packing with consecutive friction, vapour baths with consecutive shower baths and vapour poultices*, are the means which we principally make of use for this purpose.

One more way is open to us for the removal or modification of some of the phenomena dependent upon hyperæmia and congestion. This is *the reduction of the temperature of the*

body, and more particularly of the blood; a cooler blood stream is also adapted for subduing hyperæmia, heat, and pain, and nutritive disturbances in inflammatory processes, as we may deduce from Samuel's investigations. In this case it will be particularly *the general heat abstractions*, in the form of *changed packings with consecutive half-baths*, or in the form of the latter alone or of *partial packings*, as well as in the form of *larger refrigerating apparatus*, *cooling bladders*, *ice cushions* and similar procedures, of which we will make use in order to accomplish our object. By *stimulating certain secretions*, e.g. that of the bowel, we gain another mode of counteracting many congestive conditions in other parts of the body by increasing the capacity of the abdominal vessels, and for this purpose the methodically applied *irrigations* and enemata are drawn into requisition.

The *antihyperæmic*, *anticongestive and antiphlogistic method* then consists partly in thermal nervous stimuli (i.e. *nervines* and *revulsives*), which control the lumen of the vessel and the blood supply, in *antipyretics* which lower the temperature, and in *derivatives* which conduct the blood away from the part. By means then of a suitable combination of these several so differently operating procedures, we can obtain a powerful total effect, and the whole appropriately combined proceeding becomes *a rational anticongestive method*.

THE ANTIPHLOGISTIC METHOD OF CURE.

Where we are unacquainted with the causes of the inflammatory process, or are unable to cause their removal, we must do battle against the complexity of symptoms or the nutritive disturbances which are their source. Since in this case the removal of the inflammatory phenomena is only to be brought about by way of the organic function, and principally by the circulation, it will here be our endeavour to show how we can influence beneficially the progress of the inflammation by causing the subsidence of the circulatory disturbances which accompany it.

The treatment of the initial stages of inflammation with their phenomena of congestion, redness, increase of temperature, and swelling, coincides with the anticongestive method,

and we therefore refer to what has been already said on the subject. The anticongestive method will be of influence upon the consequence of inflammatory irritation, viz. exudation. As is well known, the greater part of the inflammatory exudation springs from the contents of the vessels, inasmuch as both fluid as well as corpuscular elements of the blood form the basis of the exudation. By means of the above-described diminution of the blood supply to the inflamed organs a favourable influence is gained over the quantity of the exudation, and it can be limited. I have shown elsewhere that by diminishing the blood supply to a wounded or ulcerated part the quantity of pus secreted can be increased or lessened at will.

In a similar manner, by carrying out the anticongestive method energetically, we can succeed in limiting the amount of the primary exudation.

That we are not desirous of applying very low temperatures to an inflamed part itself, as well as to one which is simply congested, has its foundation in the fact that very low temperatures would call forth much too intense irritative action at the place of contact; dilatation of the vessels, hyperæmia, stasis, and, according to physical laws, slowing of the capillary circulation would set in. Centrally to the inflammatory focus, or at a distance from it, such an impression is more allowable, as it might act to a certain extent derivatively upon the inflamed part.

It is therefore a principle in the treatment of the initial stages of inflammation *to keep the diseased part itself cool, but the vascular and nervous tracks leading to it must be kept cold.* The energetic application of cold to the nervous trunks leading to the diseased organ fulfils yet another indication, namely, the lowering of increased nerve irritability, and lessening of the pain combined with the inflammation, as the influence of cold upon the nerve trunk is to reduce the irritability and conductivity down to its peripheral distribution, and in this way it is capable of moderating the inflammatory pain.

In inflammations of parenchymatous organs situated very deeply, the principle just established will have to be departed from, in so far as the supplying vessels cannot be directly in-

fluenced. Here therefore it will be necessary to resort to the energetic application of cold over the diseased organ itself, in order to cool through the tissues down to the inflamed part; but it must also not be neglected to call forth contractile activity in the inflamed organs through reflex points, and to lessen their blood supply by means of derivative procedures, as well as finally to reduce the temperature of the blood itself by general procedures.

When energetic cold impressions are made upon the surface of an inflamed organ, or over one very deeply situated, the temperature of the skin and of the fluids circulating therein only, will be lowered. By cold applied very energetically we will, it may be presumed, produce external dilatation of the vessels very rapidly. It need not however be feared that this local action will extend to the deeper tissues. The external application of cold does not so easily become a relaxing stimulus to the deeply situated vessels, but, as we have previously described, much rather a contractile stimulant, since, as is mostly the case, the peripheral and deep vessels stand in anatomical connection, and interference such as this must bring about a lively determination of blood to the skin over the diseased organs and from them. This action will then also operate derivatively upon the inflamed organ. A further problem for antiphlogistic therapeutics to solve consists in the promotion of the repair of that disease of the walls of the vessels which is the cause of the inflammation, according to our present views, and the removal of the inflammatory products, as well as of the disturbances of function dependent thereon. The well-known fate of the exudation is either absorption and excretion by the various secretory and excretory organs, or organisation, fatty metamorphosis, induration, suppuration, and the various forms of necrosis. The ideal cure still remains absorption and excretion, whereby the diseased organ, granted that no permanent injury has been inflicted through the exudation, is brought back to its normal condition. This absorption as well as the restoration of the diseased vascular wall can only be attained through the agency of an active interchange of the blood in the diseased organ, and supported by strengthening and stimulating all the organic performances in the diseased organism.

It will be chiefly our endeavour, therefore, in the treatment of any inflammatory exudation, *to divert a sufficient amount of blood to the place where the inflammation has been progressing and where are the products thereof.* Whereas it was our endeavour in the early stages of the inflammation to diminish the blood supply to the inflamed organs, we will now direct all our attention to the formation of the blood supply and fluids to and through the diseased organ. *A great advance made in our antiphlogistic therapeutics must be ascribed to the recognition by pathology of the process of inflammation, and the recognition that the diseased vascular wall can only be restored to normal again by extensive contact with normal blood, and that only by active transformation of the blood can the desired absorption or organisation of inflammatory products be promoted.*

It is quite irrational to proceed anticongestively beyond merely the very initial stages of inflammation. The really antiphlogistic curative measure consists in congesting the inflamed organs.

To seize the right moment for beginning the congestive method is the most important and difficult problem of the rational therapeutist.

Different methods are at our disposal for this purpose and they consist in—

1. *Strengthening the heart's action.*

2. Bringing about contraction in a larger vascular district, so as to cause a collateral hyperæmia in the diseased organ and a lively reactionary fluxion from it.

3. *The establishment of local hothouse conditions* for the diseased organ, by placing it under the constant action of a moist blood-warm vapour.

4. *General procedures which, by calling into requisition certain collateral aids, influence the blood itself and thereby the processes of diffusion in the diseased organ.*

5. *Strengthening the whole organism* and its nutritive functions.

Ad 1. In the section on the hydriatic method we have made the acquaintance of procedures and conditions for strengthening the heart's action. Transitory thermal stimulation, shampooing,

short shower baths, and tepid ablutions strengthen and slow the heart's action, and accelerate and deepen the respirations.

Ad 2. Collateral hyperæmia and retrofluxion are brought about by thermal stimuli, which call forth a contraction of a larger vascular province. The collateral hyperæmia, increased pressure, and increased tension in their districts lead to a reactionary contraction of the vessels, which causes a more rapid change in the blood current, and thereby acts beneficially upon the interchange of the blood with the inflamed organ.

The mechanical influences—percussion, stroking, massage—and the powerful thermal impression are to be considered as effectual promoters of the circulation of the fluids, since by repeated compression and relaxation both the currents of blood and of fluid are promoted, and a more rapid interchange of the streams is again the result.

In this case the choice of the several procedures required depends upon the nature of the case, and it is presumed that the different fulfilments of the indications may be easily deduced from the general laws for the modus operandi of thermal and mechanical influences already discussed.

Ad 3. Of the moist vapour we have explained in the description of the methods that it is powerfully congesting, and operates by promoting processes of diffusion and absorption, without however being at present in a position to follow into all its details the how and wherefore of its effectuality.

Ad 4. No further proof, however, is needed to show that the stimulation of certain functions, e.g. the sweat and urinary secretions, exerts a powerful influence over the watery constituents of the blood and its salts, and will alter the processes of diffusion in the tissues very effectually.

An appropriate combination of these different processes will, for these reasons, be of beneficial effect upon congestion, accelerated motion of the blood, the interchange of the currents, processes of diffusion, solution, absorption, and perhaps also upon purulent transformation of the exudation. Since, however, all these procedures are based upon a more rapidly acting interchange between the exudation and the vascular system, and a more copious saturation with blood, the reason is chiefly to be found in the fact that under such circumstances a necrobiosis

will set in much less frequently in the exudation; hence we will not only observe fatty change, caseation, disintegration and gangrene much less frequently as consequences of inflammations which have been thus treated, but rather more frequently we will see the restoration of the vascular wall to its normal condition, and absorption or organisation of the inflammatory products taking place. It is upon these processes that the often astonishingly favourable results derived from the hydriatic treatment of inflammatory affections are based. It may be that in addition a great influence is exercised over this favourable issue by the strengthening of the organism under general hydriatic procedures, concerning which we shall yet have an opportunity of speaking.

Not in every form of inflammation is it advisable to proceed anticongestively *ab initio*; indeed it is often much more suitable in some cases to bring about a rapid interchange of currents from the very beginning. In this way we may sometimes succeed in really arresting certain forms of inflammation. This applies more particularly to various neuralgias, probably due to neuritis, and to catarrhal and rheumatic processes.

As is well known, the disease of the walls of the vessel which, according to our present knowledge, is the cause of the inflammatory process, arises when any interruption is caused in the contact of the blood with them. All catarrhal and rheumatic processes, perhaps rheumatic nerve diseases as well, probably come to pass by thermal reflex irritation, which represents the primary cause of the disease, bringing about a permanent vascular contraction in the predisposed organs, the neurilemma, nasal mucous membrane, and the muscles. This vascular contraction may lead to bloodlessness of a certain vascular province, which again gives rise to nutritive disturbance in the particular vascular wall—that is, in other words, to inflammation. It is easily imaginable that thereby, and in consequence also of the circulatory disturbance, retrogressional products of metabolism may accumulate in the several organs and contribute to the local disturbance. If, then, we rapidly call forth a collateral hyperæmia and reactionary determination to the particular organ immediately after the appearance of such nutritive alterations,

and bring about a more rapid change of current in it, it is always possible that the restored contact between the wall of the vessel and the now increased amount of more rapidly flowing blood may quickly make the vascular wall normal again, and thereby remove the cause of the inflammation. If, at the same time, the accumulated retrogressional products, either of function or of the tissue metabolism, are washed away and neutralised by the alkaline blood fluid, the whole process may be arrested thereby.

Short and powerful thermal and mechanical stimulations, then, which bring about a lively reactionary fluxion, are capable of actually arresting such processes; this may be rationally understood from what has just been explained, and is also corroborated by experience, so long as no more profound alterations have taken place. Derivative and sudorific procedures, long-continued fomentations of the skin of the whole body, or of the skin over the diseased organs, with consecutive procedures calculated to elevate the tone of the vessels, are here to be made use of. We may therefore consider vapour baths with consecutive shampooing, sheet or shower baths, wet packing carried to a high degree of heating and followed by like procedures, as well as the alternating action of cold and heat, of the spray douche with consecutive cold affusion and vapour poultices, followed by a cold operation, to be procedures capable of checking inflammations of recent occurrence.

Experience affords us numerous examples of the great benefit to be derived in chronic forms of inflammation also from congesting the inflammatory focus, or fomenting it with moist vapour.

We know that inflammations in anæmic tissues, or under an obstructed blood supply, or when the vessels themselves are compressed by the inflammatory exudation, are very liable to lead to the various forms of necrobiosis. Molecular disintegration, fatty changes, caseation, and even sphacelus or gangrene, are the alterations which inflammatory products undergo when the circulation is obstructed or arrested.

If this view be correct, and everything speaks in its favour, the only rational directly causal indications consist in promoting the flow of the blood and fluids to, from, and within the

diseased part, in facilitating the interchange between the blood and the diseased tissue, and, by soaking it in moist vapour, elevating the processes of diffusion and cell-life.

The best example of the benefit to be derived from such prolonged congestion and soaking is offered by caseating, superficial and indurated groups of scrofulous glands in the act of disintegration. We often observe, under moist fomentation continued for weeks or months, softening, absorption and cure taking place in these glands.

The moist, blood-warm vapour surely also penetrates the epidermis, and acts in a similar manner upon organs more deeply situated. Reactionary inflammation, separation, and disintegration, as well as expulsion and absorption, are often enough observed under the warm, moist, 'Madeira-like' intimate atmosphere (as I have called it) which is established over the chronically infiltrated lungs.

How to proceed in each individual case cannot here be laid down. The choice and combination of the procedures must fulfil as completely as possible the indications principally mentioned above. Every conscientiously undertaken test will verify that the so-called stimulant compresses have been hitherto much too underrated.

THE ANTIPYRETIC METHOD OF CURE.

The hydriatic curative procedure in fevers must not be considered as an *antithermal* method alone. In the widest sense of the term it is most certainly an *antipyretic action* which we are in a position to exercise by a suitable combination of the different hydriatic aids.

The body temperature may be reduced in heat abstractions without simultaneously elevating the heat production; indeed, most probably the latter will also be diminished. If this, however, be the case, then the hydriatic procedure will be not alone *antithermal*, but also *truly antipyretic.* The thermally diminished heat production and the reduction of temperature go hand in hand with retardation of the metabolism.

A chief factor in hydriatic antipyresis consists surely in the antithermal procedure; in this case, the physical necessity that different temperatures in contact with each other must

become equalised, is demonstrated in the living organism. For this purpose it is absolutely necessary that we should be quite clear as to the problems it is required to solve.

The living human body offers different conditions from a lifeless, heated mass consisting of several layers. Even in the latter the equalisation of the temperature with a medium of lower temperature would be dependent upon a great number of conditions: for instance, firstly upon the difference in temperature between the opposing surfaces, then upon the duration of their contact, upon the condition of the heat-discharging surface, and the heat capacity and conductivity of the heat-abstracting body. There would be also the chemical constitution and the content in gas and salts of the heat-abstracting medium to be taken into consideration. Furthermore, the amount of the heat convection from a solid to a fluid body would be dependent upon whether the latter was in motion or at rest, and, finally, upon the measure of the agitated fluid.

The magnitude and rapidity of the refrigeration of the warmer body will, besides, depend upon the proportion of its surface to its cubic content, upon its aggregate condition, the homogeneity of its structure or its stratification, and the conductivity of the several layers.

The conditions under which the discharge of heat from a living animal body takes place, however, are yet more complicated. We know that the most powerful laboratory in the body for the production of heat is to be found in the muscular layer, and that the blood, which circulates through all organs, is the most efficacious agent for the equalisation of temperature between the different layers of the body, and also for the discharge of heat by the cutaneous surface. The circulatory conditions altered under heat abstraction from the external surface of the body, also very materially alter the physical conditions for refrigeration. The heat discharge from the surface of the body will then be dependent, quantitatively, upon the diameter of the cutaneous vessels and the rapidity of the blood current within them, as well as upon the difference of temperature between the surrounding medium and the surface of the body.

In order, therefore, to keep the amount of the heat

discharge from the surface of the body constant, one would require to be able to keep the rapidity of the circulation and the diameter of the vessels of the skin constant. The blood vessels, however, are by no means stiff tubes; their lumen is alterable, and the rapidity of the current is also unequal.

Since, then, thermal stimuli are here also the most powerful means for altering the circulatory conditions, we will readily understand the value which must be attached to an appropriate technique for the reduction of the body temperature by means of hydriatic procedures.

It would here be too great a digression were I to repeat all the proofs which I have brought forward of the often directly antagonistic effects of refrigerations, as I have laid them down for the greater part already in the Second Section.

The chief problem lies in overcoming the automatic heat regulation of the body, and the chief means for this is furnished by the constantly maintained dilatation of the peripheral vessels before, during, and after the heat abstraction. Because physiologists and clinicians did not sufficiently value the alteration of the physical and physiological conditions of heat discharge and heat production under altering circulatory conditions, they were always without the key which would have explained the contradictory actions of refrigerations. The effects of the heat-abstracting treatment are, without the accurate observation of this factor, entrusted to chance, whereas in the other case they must, at least in their influence over the body temperature and the alterations of nutrition dependent thereon, be estimated *ab initio* with almost physical certainty.

If my investigations have shown that even dry friction of the surface of the body brings about an alteration in the distribution of blood and heat, this must apply in still greater measure to the combination of thermal with mechanical stimulation. In all procedures undertaken for the purpose of actually reducing the temperature of the body, the most important task is to prevent the thermal contraction of the cutaneous vessels, and thereby to anticipate collateral hyperæmia within the muscular layer.

I reiterate this so often because, even at the present time, sufficient stress is not laid upon this capital indication, and

yet upon its fulfilment alone the rational justification of hydrotherapeutics in febrile diseases is dependent.

During the refrigeration if a contraction of the cutaneous vessels be restrained by the combination of a thermal with a suitable mechanical stimulation, an increased blood supply to the skin will be brought about, and the sensory nerve-endings will be copiously saturated with warm blood.

The strong heat current prevents a too rapid penetration by the cold to the internal organs, whilst the constantly renewed blood stream conducts great waves of heat to the periphery, and prevents too profound a refrigeration of the surface in spite of an enormously increased heat discharge. The difference in temperature between the skin and the heat-abstracting medium is always restored again, and kept nearly constant. The wide current of blood in the skin prevents a collateral hyperæmia of the muscular layer, and an elevation of temperature therein; consequently the production of heat is not increased either. I have explained before that it is not a matter of indifference in what manner the elevated body temperature is reduced and kept low, and I now once more repeat that *the reaction of the organism to heat abstraction depends upon the manner of its application.* I showed that heat production which was elevated reactionarily by heat abstractions was not dependent upon the magnitude of the latter, *but upon the extent of the thermal nerve stimulation and the degree of actual cooling of the peripheral sensory nerve-endings.* I showed that this reactionary elevation of the production can be obviated by avoiding, as much as possible, a refrigeration of the terminal distribution of sensory nerves, and by actual reduction of the body temperature, and that one of the most important conditions for this lay, again, in the dilatation of the cutaneous vessels. According to Voit, *febrile temperature can only appear when there is a simultaneous failure of the heat regulators in the skin, be the production of heat ever so much increased.* The best means of bringing about its disappearance can only be found in the restoration of the cutaneous function mentioned.

The body temperature may be reduced in the most diverse ways, and yet a contraction of the cutaneous vessels be avoided.

These indications may be fulfilled by means of slapping and shampooing, together with repeated drenching of the wet sheet—sheet baths—when the procedure is carried on long enough, say twenty to twenty-five minutes, and is accompanied by mechanical action, technically well carried out. It must be counted an error in treatment when the sheet bath, and every other form of heat abstraction in fever patients, is kept up for too short a period, and withdrawn before it has succeeded in materially reducing the body temperature. The appearance of rigor is delayed by simultaneous mechanical interference, although the abstraction of heat is thereby certainly prolonged and increased.

The body temperature can and must be reduced to near its normal limit in every antipyretic procedure. This succeeds in many forms of fever indeed with the first procedure, when it is properly carried out; but there are more resistant forms of fever in which this is not at first possible. In the later progress of the treatment it will be only seldom that we shall fail in attaining, at the very least, considerable positive bathing effects.

Just as in the sheet bath, the friction of the surface of the body in the half-bath during its whole duration is a powerful means of support to the thermal interference. The effectuality of the bath is considerably increased by this combination, as I have proved by means of striking experiments, and the unpleasantness of the bath becomes thereby much lessened even when the selection has fallen on water of very low temperature, whilst the after effect is much more powerful. Unless particular reasons exist for our doing so, we will seldom select water of higher temperature than 24° C. for antipyretic half-baths, and seldom lower than 15° C. The duration of the bath will be variable; I have often been obliged to continue it for from six to thirty minutes at a time.

The resistance of the elevated temperature and its degree, as well as the antipyretic effect which one soon learns to estimate even during the bath, must define the limits of its duration. The physician should always be present at the first antipyretic procedures, so as to be able to direct the necessary

modifications of further heat abstractions, and to regulate their duration.

After some practice it is possible, by palpating certain portions of the body traversed by large vascular trunks, e.g. the axilla, to recognise very soon whether not only the surface of the body but also the temperature of the blood has undergone refrigeration. For example, the axillary artery, although the surface of the body is already very much cooler, is felt passing through the axilla like a hot cord ; this signifies that the heat abstraction must be carried on to a much greater degree, or on the other hand, that a sufficiently antipyretic effect has already been attained, and that the bath may be concluded. The frequently changed wet pack, whose *modus operandi* we have already discussed under the heading of the technique of the water cure, is an effectual antipyretic procedure by which heat abstraction may be undertaken without simultaneous mechanical stimulation, and without causing a contraction of the cutaneous vessels. I will here only repeat that if this procedure is to be followed by good results, the changings of the wet pack for antipyretic purposes are not to be suspended until actual moderation of the fever has taken place.

The truncal compress is a supporting measure in the reduction of febrile temperature, but it is especially useful in keeping the exacerbations asunder, and in maintaining the temperature at a low degree after one of the heat-abstracting procedures just mentioned. I have demonstrated by experiments that the application of truncal compresses between the several antipyretic procedures is effectual in retaining their antipyretic effect for a longer time, thereby separating the periods of exacerbation more widely, and rendering it possible in the treatment of fever to obtain the desired limit after a small number of individual procedures, during a period of twenty-four hours.

The following comparative table, taken from my 'Hydrotherapie auf physiologischer und klinischer Grundlage,' may here find place to demonstrate the antithermal value of certain hydriatic procedures in fever. I there said—

'This table, I must confess, is set up from too small a number of individual cases, as I could only make use of cases of nearly

equal value for each of the procedures compared, and could only now and then keep sufficiently minute records of temperature with the material at my disposal, which, for acute diseases, originated entirely in private practice. Out of the said material, one disease only, viz. typhoid, was selected, and the mean of the rectal temperature prior to the refrigeration calculated for the particular day of the disease, for each group separately.

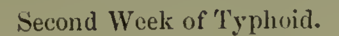
'The mean of the antipyretic effect of the procedure undertaken in each group and at equal periods of time, was then placed in the table, which gives us not alone the mean magnitude of the antipyretic effect of each of the procedures contrasted, but also the duration of the after effect—the temperature reduction.

Table showing the extent and duration of the antipyretic effect of various hydriatic procedures in different stages of fever.

Fever stage	No. of cases	Procedures adopted	Mean rectal temperature prior to the cooling procedure. Degrees C.	Mean reduction or elevation of temperature after					
				30 ms.	1 h.	2 hs.	3 hs.	4 hs.	5 hs.
Second week of typhoid.	3	Half-bath at 18° to 16°, duration 15 ms.	39·8	— 0·87	— 0·56	— 0·37	— 0·18	+ 0·23	+ 0·40
	2	Repeated wet packings, duration 1 h. 20 ms. to 2 hs. 35 ms. Thereafter half-bath, 18° to 16°, 10 ms. duration	39·6	— 1·21	— 0·93	— 0·73	— 0·31	— 0·17	— 0·02
	4	Half-bath, 18° to 16°, 15 ms., followed by truncal compresses changed half-hourly	39·8	— 0·73	— 0·8	— 0·54	— 0·42	— 0·13	— 0·03
Fourth week of typhoid.	2	Half-bath, 18° to 16°, duration 15 ms.	39·9	— 1·3	— 1·09	— 0·94	— 1·04	— 0·7	— 0·3
	3	Repeated wet packings, 1 hr. 20 ms. to 2 hs. 35 ms. Thereafter half-bath, 18° to 16°, 10 ms duration	39·8	— 1·6	— 1·3	— 1·4	— 0·91	— 0·7	— 0·8
	3	Half-bath, 18° to 16°, 15 ms. duration; consecutively, truncal compresses changed every half-hour	39·7	— 1·2	— 1·3	— 1·0	— 0·96	— 0·66	— 0·70

'Notwithstanding that the table, as may be seen, is collated from rather meagre material, it yet seems to me to possess some slight value, as apparently a general law may be deduced

Course of the temperature after refrigerations by means of various hydriatic procedures in different stages of fever.



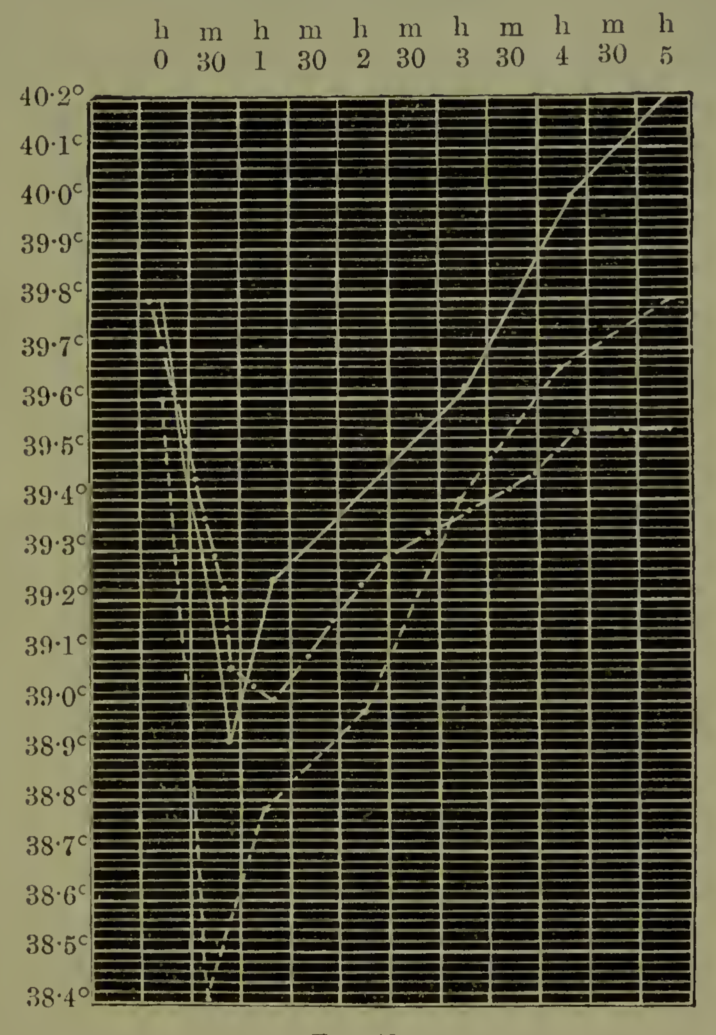


Fig. 48.

Explanation of the Curves.

———— Half-bath at 18° to 16° C.; duration, to 15 ms.
– – – – – Repeated wet packings, consecutive half-bath at 18° to 16° C.; duration, to 10 ms.
.—.—.— Half-bath at 18° to 16° C., to 15 ms.; consecutive truncal compresses, changed half-hourly.

therefrom which harmonises well with experiences gained in another direction.

'A glance first at our table, and then at the charts constructed after it (figs. 48 and 49), suffices to make it manifest that

the body is more resistant to any form of heat abstraction in the early stages of fever than after the latter has been already existent for a some time. Procedures of like value reduce an almost equally high body temperature lower in a later

Course of the temperature after refrigerations by means of various hydriatic procedures in different stages of fever.

Fourth Week of Typhoid.

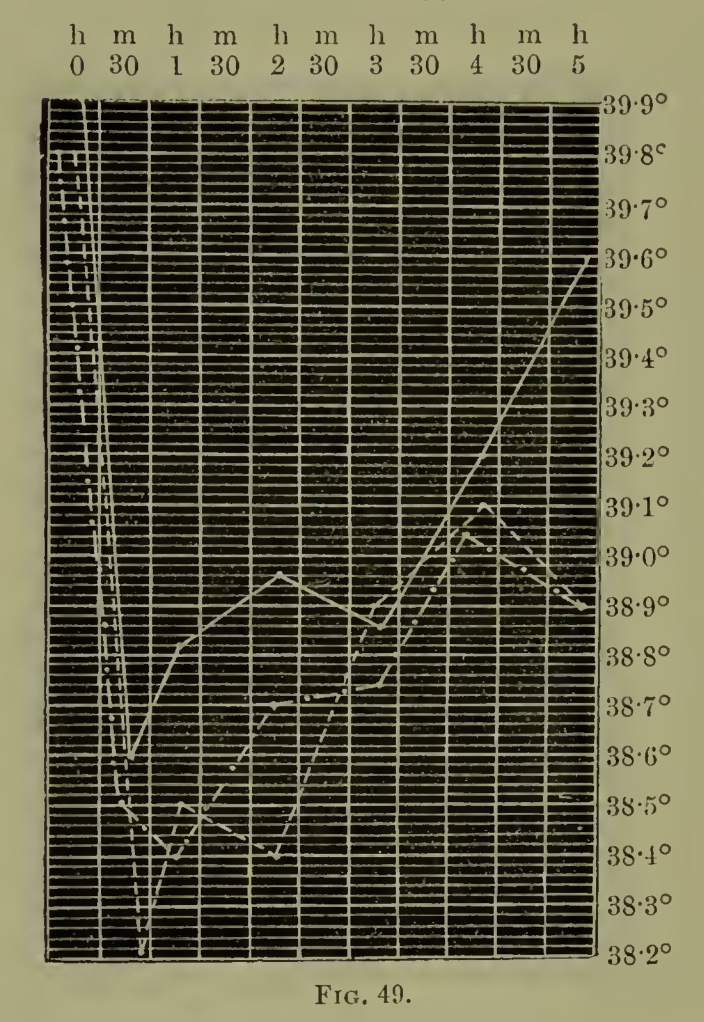


Fig. 49.

Explanation of the Curves.

——— Half-bath at 18° to 16° C.; duration, to 15 ms.

– – – – Repeated wet packings, consecutive half-bath at 18° to 16° C.; duration, to 10 ms.

.—.—.— Half-bath at 18° to 16° C., to 15 ms.; consecutive truncal compresses, changed half-hourly.

period of fever than in an earlier one. Both table and curves further show, that after every form of the contrasted heat abstractions, the subsequent ascent of the body temperature is much more steep in an early week of fever than in the

following. The selected heat-abstracting procedure, however, seems to be of standard influence on the absolute degree of rewarming after a refrigeration.

'In the second, as well as in the fourth, week of fever, after the original fall, we see the body temperature ascending much higher when the half-bath was administered by itself, than after repeated wet packings, consecutive to a half-bath or after a half-bath and succeeded by half-hourly truncal compresses.

'A material difference, however, here again displays itself between the bearing of the second and of the fourth fever week. After a half-bath, the temperature during the former rises considerably over the previous heat in the fourth hour after the bath; and this ascending tendency, although a little less steep, is carried on even into the fifth hour. In the fourth fever week, the body temperature is materially lower than before even five hours after a simple cold half-bath.

'It has been recently established—it could only be established by the method of examination here described, and in so far as sparse material allows of drawing certain conclusions—*that the rewarming after heat abstractions, carried out by means of packings and half-baths, follows more slowly* in every period of fever than after simple half-baths, and that *truncal compresses will prolong the action of the cooling process*, and delay the re-ascent of the body temperature. That this is a justifiable conclusion is apparent, since the same result was observed in both fever periods. It would be most salutary were the numerous clinicians, who have at their command a large amount of material for observation, to test the different hydriatic antipyretic procedures, in the various diseases accompanied by fever, as to the extent and duration of their antipyretic effect, the method being of course scrupulously adhered to. By such an investigation alone can the value of the several procedures, and a strict indication for each of them, be really scientifically established. Even my defective investigation, however, will suffice to show that it is judging rather hastily when it is alleged to be a matter of indifference in what manner a febrile elevation of temperature is combated.'

Certain hydriatic procedures even have influence over many of the etiological causes of fever. I have demonstrated that

heat retention must be considered as a material factor in the febrile elevation of temperature. Of course it is necessary that an elevation of temperature should follow heat retention, as well as a more permanent disturbance of the compensatory apparatus contained in the skin function itself. Heat retention manifestly plays a considerable part, especially in the beginning of fever and the rigor stage of many febrile diseases. That by means of appropriate hydriatic procedures it is possible to cause the subsidence of heat retention, I myself have proved by means of calorimetrical investigations. All procedures causing a dilatation of the cutaneous vessels, and acceleration of the circulation in the dermal organ, or strengthening the heart's action, will also set free the retained heat, or at least will diminish the retention.

By the liberation of retained heat another object is fulfilled simultaneously, which removes one of the conditions for the febrile elevation of temperature. It is, namely, that *the retention of water* within the organism, which may be regularly assumed to take place in the stage of pyrogenesis, is acted against, and by this removal of water retention one of the abnormal processes in fever patients is removed; thereby most probably a great deal has been contributed towards facilitating the quicker resolution of the disturbance, and the liberation of retained heat and water will also increase the effectiveness of the antithermal procedures of hydrotherapeutics. Positive bathing effects will turn out much more considerable after the removal of both these febrile symptoms.

For these reasons, then, I *consider the liberation of retained heat and water to be the primary indication in the hydriatic treatment of fever*; it is, as it were, a preparatory measure for a subsequent and more energetic antipyretic interference. These indications will be best fulfilled by means of ablutions, shampooing, shower baths, powerful friction over the whole surface of the body in the bath, and, under certain circumstances—particularly in cases of very dry skin, or in very exalted irritability of the vasomotor nerves—wet packings with consecutive shampooing or half-baths.

A single and only momentary dilatation of the cutaneous vessels will not be sufficient to carry out the requirements of

an appropriate antipyresis, even though the cutaneous circulation be thereby increased, and liberation of retained heat and water take place to some extent; in fever the heat retention must be permanently suppressed, and *a constant and increased heat discharge kept up.*

A further very important indication in antipyresis consists *in the constant keeping down of the body temperature during the whole course of the fever*, and in attacking every fresh exacerbation as it arises. This applies not alone to the treatment of typhoid fever, but to every form of fever accompanied by long-continued elevation of temperature. The dangers of an elevated body temperature, particularly of a long-continued one, are too well known to require a separate description here. If our therapeusis succeeds in moderating and lowering the febrile temperature permanently, we shall have rendered the patient a decided service in the majority of cases, and will have often directly preserved life.

To keep the temperature down continuously throughout the whole progress of the fever, comprises the combating of each single exacerbation of fever, and the greatest possible separation between the occurrence of exacerbations. It is impossible to define beforehand, which and how many procedures will suffice during a period of twenty-four hours to obtain the most complete result possible. It must, however, be conceded, that the various forms of baths may fulfil the indication, and that the choice of temperature, the duration of the several heat-abstracting procedures, and the manner in which they are carried out, are of great influence upon the result, as is also the bearing during the interval following the baths.

It is all the more difficult to fix any laws and rules relating to this subject, as the individual and the pathological conditions present very great variations, and require to be considered in the selection of the method. There are individuals and forms of fever in which each single heat abstraction, no matter in what form, always brings about a sufficient and durable antipyretic effect; on the other hand, there are individuals and cases of disease in which even very energetic heat abstractions are capable of producing only a very insignificant and transitory positive bathing effect. It

is an established fact that at the commencement of *severe febrile affections* the positive bathing effects obtained are inconsiderable and less durable than in the later progress of the fever. The case is different in ephemeral fever, catarrhal and some eruptive fevers, in which often a single, or at most a few refrigerations suffice to moderate the fever permanently. The selection of the *time* for the application of the hydriatic antipyresis is also of some influence upon the result.

It is generally more difficult to interrupt the ascent of the temperature at the commencement of an exacerbation than during a remission of fever. It may be inferred therefrom that we will obtain the limit during the period of fever remission, whilst one is often forced to apply refrigeration *coup sur coup* during the period of exacerbation.

The observance of the reactionary laws will increase the durability of the antipyretic effect. Comparatively high temperatures and prolonged duration of the individual heat abstractions will, under otherwise equal circumstances, have a more durable and powerful antipyretic effect than less prolonged operations with relatively low temperatures.

All this has a great influence upon the selection and order of application of the several procedures. *The degree of febrile temperature elevation* to be combated likewise defines the methods to be chosen. High temperatures require more energetic procedures than lower febrile temperatures, and, for my part, I adhere to the principle *that every febrile elevation of temperature should be combated hydriatically from the very beginning.* Of reasons why every febrile affection should be thus treated there are very many. Only in rare cases will it be possible to determine, at the beginning of the condition, what course a fever will take, what is its etiology, and what local or general affection it accompanies.

Since it now belongs to the category of the best established pathological facts, that in the fever itself lies the cause of the most numerous dangers, that the fever, no matter what organic disease it accompanies, forms a complication the removal of which will diminish greatly the alarming aspect of the case as well as the sufferings from the affection, and that the local affection takes on a usually more favourable course when the

degree of fever is lessened, it must always be our endeavour and first task to allay the fever or at least to moderate it.

Experience has taught us that a recent fever is frequently subdued more easily by a hydriatic procedure than one of longer existence, that with the duration of the fever the dangers combined with it grow in proportion, that the disturbance of nutrition consequent on the high temperature may be anticipated by means of a methodical reduction of the temperature from the very beginning, that many forms of fever may, by early cold impressions, perhaps be arrested, and that this is possible even in forms of fever dependent upon infection, as the fever ferment can only develop its action at a definite high temperature. I am, therefore, perhaps justified in laying down as the most urgent indication, *that every fever should be combated as early as possible.*

Much less favourable are the results when the hydriatic antipyresis has been introduced only in the later course of the fever, when alterations in the parenchymatous organs, molecular disintegration, fatty degeneration and so on, have already taken place. The selection and carrying out of the method has often to depend upon the bearing of the nervous system, the condition of the heart, and the circulatory conditions.

As a general rule, therefore, we will proceed to more powerful heat-abstracting procedures, when the phenomena of heat and water retention have been removed, through dilatation of the cutaneous vessels and acceleration of the circulation in the skin, and the body has been prepared for the easier discharge of its heat.

The most certain guide for the amount and frequency of the necessary heat abstraction is the thermometer; as soon as the temperature in the rectum or in the axilla has passed 39° C., the indication for cooling procedures is always present. The indication for them will be more urgent when this degree of temperature exists at the moment of a commencing exacerbation, and when a repeated examination has proved a tendency to still further ascent. A continued fever furnishes the indication for hydriatic interference indeed in comparatively lower temperatures than a remittent, or perhaps even intermittent form of fever; a febrile process of probably longer duration,

requires a refrigeration at comparatively low temperatures, whilst in affections in which a natural decline of the fever may be expected within a short time, the indication for refrigeration only becomes imperative when the temperature is much elevated. Pathological symptoms displayed by the nervous system may necessitate the selection of certain procedures. Delirium, disturbances of the sensorium, coma and sopor must be combated by means of the most excitant and rousing hydriatic measures; shower baths, affusions and drenchings in the tepid bath or in the empty tub are here indicated. Threatening or existent collapse does not prohibit hydriatic action either; yet here, however, the heat abstraction must be slight, the stimulant action a more powerful one. Collapse with excessive heat, and caused thereby, does not permit of any absolutely great refrigerations, but frequent minor ones combined with a suitable nervous stimulation here find their application. The reduction of the body temperature in fever does not remain without its effect upon another fever symptom, namely, the accelerated cardiac action and the movement of the blood. The heart's action may be very effectually modified by means of certain procedures, such as repeated wet packings. The alteration in the circulatory conditions through the slowed and more powerful action of the heart, must be of favourable effect upon the manifold intimate nutritive processes during the progress of the fever. It is particularly the diminution or complete removal of the danger of collapse which comes into consideration here. It is true, we must admit, that an inappropriate hydriatic antipyresis is also capable of increasing the danger of collapse. Too sudden and too powerful heat abstractions in advanced stages of fever, when the heart is already weakened, and the alterations in the parenchymatous organs well advanced, might possibly favour the advent of collapse, for the weakened heart might be unable to overcome the circulatory obstructions so suddenly increased through the cold influence.

By means of a suitable method, however, we will be able to directly anticipate imminent collapse or banish it if already set in. Increased innervation, reduction of temperature and the removal of circulatory obstructions, are the conditions necessary for this purpose. By strengthening the heart with alcoholic

stimulants prior to each heat abstraction, anticipating or removing irregularity in the heat distribution, reducing the temperature only very gradually, and perhaps by supplying heat to individual parts of the body directly or depriving others of their heat, the indications established will be amply fulfilled, provided the measures are properly carried out. The administration of a mouthful of wine before each refrigeration, warming the hands and feet either by mechanical friction or by warm applications, cooling the trunk by means of industriously changed truncal compresses, and, in cases of greatly lowered function of the central nervous system or disturbances of the sensorium, the affusion of cold water upon the head from various heights, either whilst in the empty tub or in a warm bath—all these are procedures under which, when appropriately combined and carried out, one often sees severe collapse disappearing. One of the greatest advantages of antipyretic hydrotherapeutics consists in the possibility of diminishing the febrile consumption; this is accomplished by means of an antithermal procedure in two ways—namely, in the first place, by the fact that at a low temperature the metabolism is retarded, as already mentioned above; and in the second, by the possibility of administering a more strengthening diet to the patient, since under low temperatures neither the appetite nor digestion are as much interfered with as in higher degrees of pyrexia.

That the febrile metabolism under the artificial reduction of temperature becomes much more like the normal, is manifest from the fact that neither the secretions nor the excretions undergo the same changes as they do under higher temperatures. Beginning at the mouth, and then carrying our examination down the whole digestive tract, and also into the uropoiëtic system, we find alterations setting in during hyperpyrexia which are not present when it is moderated. Whilst in high temperatures the secretion of saliva disappears almost entirely, the tongue becomes dry and encrusted, and the oral cavity has an acid reaction, we observe that the tongue cleans and becomes moist, the secretion of saliva again appears, and the oral secretion gives an alkaline reaction shortly after the temperature (and it only) has been operated on.

It has been rendered probable of the remaining secretions,

as well experimentally as also by clinical observation, that in very high temperatures they display great alterations, and return to normal when the temperature is lowered. That the gastric secretion ceases, and that the peptonising action of the gastric juice upon albuminous substances is lost during the existence of high temperatures, was proved by experimental pathology long ago. Clinical observation shows that the quantity and quality of the urinary secretion rises and falls in proportion to the temperature. I have also always observed it to be one of the most favourable prognostic and earliest of signs in hydriatic antipyresis whenever a more copious secretion of much less consistent and light-coloured urine containing less uric acid took place. Refrigeration, then, when circumstantially and methodically carried out, acts in a very powerful and beneficial alterative manner upon the whole tissue metabolism of a fever patient.

To summarise, then, the method of hydriatic antipyresis consists in an antithermal procedure and in interference which acts upon innervation and the circulation analogously to the nervine tonics and sedatives; and in tone-giving factors which influence nutrition in a favourable manner, as well as in local antihyperæmic and anticongestive procedures, which simultaneously influence these local processes.

The more accurately we can adapt the hydriatic interference to the indications before us, the more successful will the whole procedure prove to be.

FLUXION AS A CURATIVE METHOD.

As we were already able to point to the great importance of hyperæmising and fluxion, acceleration of the blood current, and more rapid change of its constitution, in causing the removal of inflammatory processes, when speaking of the antiphlogistic method, we may now more closely examine in what numerous nutritive disturbances an intentionally called forth fluxion to certain organs will prove itself to be a powerful curative agent.

It may perhaps be adduced as one of the greatest advances in therapeutics, that we have at last found out that the most operative and almost only means for the removal of nutritive

disturbances consists in influencing the organic functions themselves.

Since, then, the circulation forms the most important factor in the processes of nutrition, and the lymph stream alone furnishes the material for the organic function as well as for the nutrition of the organ itself, we shall find it conceivable that by controlling the circulation we can operate upon all the organs and their functions, stimulating, arresting, and alternating at will.

If nutritive disturbances are dependent upon diminished, retarded, or arrested blood supply to any one organ, or upon a diminished supply of blood within the whole organism—in other words, upon local or general anæmia—I shall hardly be contradicted when I maintain that an increased, accelerated, and facilitated blood supply to the diseased organ, and an increased formation of blood within the organism, must be the most certain means for removing the disturbances dependent thereupon. The treatment of local as well as general anæmia must rest upon these principles, if it is to be a rational one. It must certainly be justifiable that we endeavour to remove local anæmic conditions by means of an increased blood-supply to the anæmic parts of the body. In accessible parts the local application of warmth will call forth vascular relaxation and acceleration of the circulation most rapidly. Warm fomentations at blood heat, or perhaps a little higher, local hot water or vapour baths, or local hot douches, will, at least momentarily, fulfil the required indications.

It must, however, be observed that the said heat impressions, when only somewhat longer in duration, bring about a condition of the wall of the vessel akin to paralysis ; or, on the other hand, when applied for too short a period, in consequence of the exalted local nerve irritability, the momentary vascular dilatation during the heat supply would be followed in the simple transit to the ordinary external conditions by a spastic vascular contraction, and thereby the original pathological condition must be made even worse.

In local anæmia the indication exists for bringing about, in addition to a moderate vascular dilatation, acceleration of the circulation during retained tonicity of the vascular wall.

Short but powerful cold impressions, with rather energetic

mechanical interference, suit this indication best. Benefit may also be anticipated from the use of the alternating actions of heat and cold, and the so-called excitant forms of compresses with consecutive transitory refrigeration, in the disturbances of the circulation dependent upon local anæmia.

The procedures which we select from this point of view, will consist in dry or cold wet friction of the particular parts for from three to five or eight minutes; movable local cold douches applied for from a half to three-quarters of a minute, and, in great torpidity or slight irritability of the inhibitory nerves, local Scotch douches, or cold compresses without an impermeable layer and well covered with a dry one, will often suffice to fulfil the indications.

In all these forms of application subsequent thorough dry rubbing or massage must be performed on the particular parts. But local anæmias are also accessible, indirectly, to thermal influences by way of the thermal reflex stimulation. Here it will be the so-called revulsive actions which we must endeavour to bring about. The reflex hyperæmisation of any part succeeds best, according to experience, from certain points to which the cold or hot stimulation must be applied rather strongly for a considerable period, with an intensity which, it is to be regretted, cannot always be estimated beforehand. Since in this direction but few facts have been hitherto established, we must restrict this mode of application to some very rare cases only. As examples, the following may be here enumerated:—

Ice poultices to the lumbar portion of the spinal column cause a dilatation of the vessels in the lower extremities, and often remove habitual coldness in a remarkable manner. Anomalies of menstruation attributable to vascular spasm, amenorrhœa, and backward development of the inner genital apparatus in girls, seem to be sometimes removed by the same form of application. Warm applications to the lumbar spine will often prove serviceable in vascular relaxation of the genitals; infiltrations of the uterus, profuse menstruation, and many forms of uterine hæmorrhage and menorrhagia may be treated successfully in this manner.

Another method of causing hyperæmia in anæmic organs not directly accessible, consists in the endeavour to lessen the

total capacity of the vascular system by elevating the tonus, and causing the contraction of a larger peripheral vascular district. Thereby the blood which was obstructed in the periphery is impelled towards the several internal organs, in which an actual *plethora quoad spatium* will now set in. Together with the, in this manner, relatively increased amount of blood and the increased pressure within them, there will also appear an exaltation of their function.

In conditions of general anæmia, then, the functions of the vital internal organs, as well as of those presiding over nutrition and the formation of blood, may be elevated if required. In such cases we only imitate Nature, and support her endeavour to concentrate the little blood in the internal vital organs by contracting and elevating the tonus of peripheral vessels ; hence the habitual coldness of the hands and feet in these cases.

And even if such anæmic conditions did not depend upon a quantitative but upon a qualitative alteration of the bulk of the blood, the accelerated flow of less generous nutritive material through the organs presiding over nutrition and the formation of blood must at least improve their function.

We endeavour, by means of such thermal contractile stimuli, to obtain actions such as have been recently sought to be obtained by means of Esmarch's bandage in high-graded anæmia, by driving the blood out of the extremities. By the appropriate thermal stimulant action, innervation is increased, the circulation in the organs presiding over blood formation and nutrition is accelerated, and the respirations are hastened and deepened.

Besides the nervous stimulation, the elevation of the vascular tone and the acceleration of the circulation are of the greatest importance to the nutritive processes and the formation of blood. It is the vascular tonus which, according to the researches of the most prominent investigators, has such a directly controlling effect upon absorption, secretion and excretion, and upon the most intimate metabolic processes in the tissues. Such an action, beneficially influencing the most vital processes, must therefore have an eminently tonic effect, and herein the most striking actions of hydrotherapeutics are to be looked for.

From a theoretical point of view, the prejudicial idea that hydrotherapeutics are absolutely contra-indicated in anæmic conditions is thus put aside. It has by no means escaped our notice that, accompanying the anæmia, there is constantly also a low, irregular distribution of the body heat, and that it must seem highly irrational to anyone who recognises in hydrotherapeutics a refrigerating method only, to apply this method in local and general anæmia. Only when all the appurtenant circumstances and the conditions on hand have been taken into consideration, can hydrotherapeutics find application in the said conditions. The principles of the hydriatic treatment of local and general anæmic conditions, indeed of all processes in which a tonic procedure is indicated, will therefore be as follows :—

1. The end result of each individual hydriatic procedure in non-febrile, anæmic and debilitated conditions must never be a reduction of the temperature of the body below normal. It is therefore necessary, in order to render the action of the cold possible in all anæmic individuals, to regularly precede the actual heat-abstracting procedure by one which will either cause the accumulation of heat within the body, or supply it directly with heat.

By means of this antecedent heat accumulation or supply, the refrigeration will encounter a much more irritable nervous system ; the graduation of the process must be such that it only deprives the body of the accumulated or superfluously supplied heat, and does not reduce the temperature below normal. An accumulation of heat upon the surface of the body takes place in the morning, after a night passed in bed under appropriate coverings. Heat-abstracting operations on anæmic individuals, then, will be undertaken with particular predilection immediately after leaving bed, or, as it is usually expressed, 'out of the bed heat ;' they may also, however, follow a dry or wet packing, or a short steam box bath. Under circumstances, a moderate amount of exercise prior to the procedure may bring about the necessary heating.

2. As regards the selection of the temperature of the water for the treatment of anæmic and chlorotic conditions, I was formerly of the same opinion as the French authors, namely,

that the nerve stimulation required to bring about a suitable action and counteraction, could only be obtained by the use of a very cold medium. Although even at the present time in the majority of cases, particularly in those of very torpid individuals, I still advocate the passive application of very low-tempered water in anæmia, I have obtained very favourable results in excitable persons, even with medium temperatures.

3. Extremely anæmic individuals will not bear refrigeration very well when fasting. A glass of warm milk or a cup of tea, taken half an hour before the procedure, will usually render its application possible. Alcoholic stimulants, either alone or with milk, are often the only means of rendering cold applications endurable.

4. The result of the procedure must always be strengthening of the heart's action, an acceleration of the circulation, and elevation of the tone in the vascular system in such cases. Only thus shall we succeed in increasing the blood supply to the anæmic organs, in improving the formation of blood, and in giving tone locally and generally. It will often be surprising to observe how powerfully these minimal heat abstractions will contribute towards the removal of mixed anæmic conditions, and towards obtaining a desirable result.

One of the most striking examples of the therapeutic value of calling forth a local fluxion to an anæmic organ, is furnished by anæmia of the brain. Here, in addition to a general elevation of the vascular tone, by means of the passive application of cold to the periphery—by shampooing and shower baths—and spurring the cardiac activity thereby, it will be more especially the local direct supply of heat, and, better still, the application of excitant compresses, that will overcome the local anæmia.

It is an old-established custom, and one which has been embodied in popular medicine, to tightly encompass the head with a bandage of some kind in headache; it is only anæmic headache in which this procedure is of any service. The tight constriction of the head acts as a circulatory obstruction to the numerous vessels of the scalp; the blood thus dammed, is forced into the region of distribution of the internal carotid artery, and thereby the cerebral anæmia may be modified. Warm, dry and cold, wet or excitant

cephalic compresses, well covered in by dry layers, act by directly increasing the blood supply to the head. Of yet greater importance still is acceleration of the circulation, and the increased blood supply in various affections of the thoracic organs. Numerous processes in the lungs display the characters of anæmia, of low vascularisation, and of compression of the vessels by large masses of coagulating exudation, rich in cells. The conditions for the cure of such processes can only consist in a lively promotion of the blood supply, in copious saturation by and circulation of the blood fluid, and in that moist heat, supplied by the *excitant compresses*, which so favourably influences endosmosis and exosmosis as well as cell life. The beneficial influence of moist warmth becomes easily explicable here, when we remember that catarrhal and inflammatory processes in the lungs, and also in many other organs—such as swollen lymphatic glands, the skin and the areolar tissue—whether a specific cause has originated them or not, only display their singular progress, their singular changes and metamorphoses—different forms of necrobiosis, caseation, and induration—because the circulation has undergone some change, a limitation perhaps, in the affected part, caused either by the process itself or by general conditions. Whether now it be a misproportion between cardiac force and circulatory obstructions to the lesser circulation, which may have been caused by the various circumstances, or whether it be that a general affection has caused the cardiac weakness, they will all lead to the same result—to arrest of the circulation in the diseased organ. Under these circumstances it will always remain the most important task of therapeutics to remove the circulatory obstruction, and to increase the blood supply to the diseased organ. By means of an individualising special diagnosis, as we have shown, we will obtain a variety of methods suitable for the attainment of this object, and several of these may be adopted simultaneously. The conditions under which cure, absorption, organisation, cell-proliferation, and softening will take place, can alone be brought about, and an extensive necrobiosis often alone encountered, by means of copious irrigation with fresh blood, by continuous fomentation with moist

vapour, and by local hothouse conditions, which we must establish in the tissues.

The quite astounding results frequently obtained in recent times in affections of the thoracic organs by means of such an artificially induced fluxion to the diseased organ, will justify me in devoting yet a few words to the action of the thoracic compresses in causing congestion.

As a general rule, people do not usually make clear to themselves in what way compresses placed on the surface of the chest influence the processes in the thoracic cavity. A well, drily-covered and therefore rapidly-heating thoracic compress, causes only a transitory stimulus by its low temperature upon the sensory cutaneous nerves of the thorax. The thermal irritation causes deep respirations to be taken, and thereby at once promotes the aspiration and propulsion of the blood, the circulation in the greater and lesser systems. Once the moist bandage covering the chest is heated—at first, to the temperature of the skin, and soon (by prevention of the heat discharge) still higher, almost to blood heat—the thorax is placed in a blood-warm vapour bath, which causes the vessels in the skin of the chest to dilate, must accelerate the circulation in them, and probably acts in a similar manner upon the vessels of the organs situated more deeply beneath the fomented skin. The reasons for this I have frequently recounted elsewhere. The influence of such thoracic compresses is probably to be traced to alterations in innervation—alterations which from the sensory nerves of the skin over the chest communicate themselves by reflex to the respiratory organs themselves. The thoracic compresses probably act analogously to the various popular measures, e.g. inunction of oil, plasters, salves, and counter-irritants, of which it cannot be denied that they often alleviate or cause the subsidence of many complaints, such as the irritation of cough, dyspnœa, and difficult expectoration. The fomentation of the sensory cutaneous nerves by moist vapour may play an important part therein, and be explained, according to Heymann and Krebs, by the enlargement by aqueous imbibition of the sensory peripheral nerve-endings, which they say will call forth a delay in conduction and a soothing effect in the particular nervous tract. As regards

the influence upon the alteration of trophic, pathical processes, the solution and absorption of old and hardened exudations, the improvement or removal of chronic catarrh, and solution and resorption of numerous inflammatory products, it is presumably the influence of the moist heat in accelerating the circulation which here makes itself most felt. The soaking of the diseased tissues with fluid in the form of vapour may also be taken into consideration, as it is well known that the skin is easily penetrated by bodies in the form of vapour.

The conduct of superficial and inflammatory exudations under moist vapour poultices, furnishes a most convincing proof that this explanation is to some extent justifiable. We here see, under our very eyes as it were, the circulation and thereby the nutritive processes and cell life, favourably and rapidly influenced, and it does not seem impossible that such an action should extend to deeper tissues. Exactly as in local anæmia, we will often observe in general anæmic conditions, and in chlorotics and convalescents in whom the condition of the blood has for a long time been defective—and who have been treated with every known tonic without any apparent effect—very favourable effects following on almost insignificant thermal actions, provided we succeed in gaining the influence just described over the innervation and circulation. We see then that the *tone-giving hydriatic procedure* consists in the combination of numerous actions, foremost amongst which is that which I have described as *fluxion*.

I consider that *congesting the diseased organ* is the most important therapeutical factor in the treatment of chronic affections of the central nervous system.

Whilst the anticongestive and particularly the antithermal procedure is suitable in allaying the symptoms of disease in the initial stages of many inflammatory affections of the cerebro-spinal axis, accompanied by the phenomena of irritation; whilst certain neuralgic affections and some forms of spasm find a very reliable curative measure in the energetic refrigeration of the seat of the disease; whilst, particularly in high-graded exaltation of the reflex excitability of the spinal cord, a thorough and really conscientious refrigeration of the spine is an almost certain means of cure—notwithstanding all this I say

that the majority of chronic diseases of the spinal cord require quite a different mode of procedure for their treatment, and this consists in bringing about a constant fluxion, or at least an increase in the blood supply to the spinal cord. The most positive and accurate diagnosis of severe anatomical lesions in the brain and spinal cord by no means excludes the possibility of a favourable issue, since the possibility of regenerating the central nervous system has been abundantly proved by experimental research. Clinical experience tells us the same thing; in numerous cases of spinal or cerebro-spinal affections, which were formerly and even at the present time are still considered incurable, it is not unusual to observe improvement and even cure taking place.

If we muster the pathological processes which accompany the majority of spinal cord diseases generally, we will find that vascular affections belong to the category of greatest frequency. Fatty degeneration, sclerosis of the smallest vessels and calcification, as well as distension and hypertrophy or atrophy of the nerve fibres and ganglia, the formation of vacuoles, fatty metamorphosis and granular destruction of the neuroglia, and hypertrophy and the formation of new tissue are the most ordinary conditions present. The processes which may here be observed are then mostly so-called necrobiotic processes, or consequences of inflammation under a limited blood supply; we already know of their existence in other organs. To the vascular disease, the anæmia, the slight vascularisation and compression of the vessels by interstitial exudation, distension of the neuroglia and overgrowth of connective tissue, must be attributed, I repeat, the necrobiotic processes and overgrowth of connective tissue which follow inflammation in the central nervous system.

When considering the antiphlogistic method, I pointed out that the best means of curing the diseased vascular wall lay in increasing its contact with normal blood fluid. I there showed that the increased supply of blood to the diseased organ is capable of preventing necrobiosis and promoting a cure. The most favourable condition, therefore, for the removal of the nutritive disturbances here present is to be found in the increased supply of blood to the affected organ.

We are also referred to increased blood supply, as fulfilling directly a causal indication, by clinical experience in the diseases of the cerebro-spinal axis in question.

Eulenberg and Charcot proved the lowered tension of the pulse in ataxic processes. In such processes, however, a very moderate circulatory obstruction—such as the inflammatory process will cause locally—must be regarded as a very significant circulatory disturbance. It will be the task of therapeutics, then, to promote the blood supply to the spinal cord, and accelerate its circulation through the same. The means for the fulfilment of this cardinal indication are to be found in an elevation of tension in the vascular system, combined with an endeavour to make this elevation permanent.

An elevation of tone in the vessels will, under otherwise equal circumstances, bring about an acceleration of the circulation. By means of thermal stimuli, we will also be able to strengthen the heart's action; a strengthened heart will more easily overcome the circulatory obstruction than a weakened one.

If we keep all the indications hitherto developed for the treatment of chronic diseases of the central nervous system, particularly of the spinal cord, before us, we shall soon be quite clear as to the selection of the procedures and temperatures to be made use of. We must avoid—and this is easily comprehensible—all very powerful thermal stimuli in such affections, as by their instrumentality the relaxed peripheral vascular system would be brought to still greater relaxation, and by increasing the richness in blood of the cutaneous vessels, and those in the subcutaneous areolar tissue, a derivation might possibly be brought about from the more deeply placed formations, which will, of course, include also the cerebro-spinal axis. If inflammation or anæmia are at the bottom of the affection in the cerebro-spinal system, the disturbance of nutrition will not be improved by such a procedure, but rather matters will be rendered much worse. For theoretical reasons also, very high and low temperatures will have to be avoided in such affections. Experience has long ago expressed itself in the same sense, inasmuch as very powerful thermal springs, and the use of vapour baths in spinal cord diseases, have, on the average, caused the affections to become worse. Similarly

intense nervous stimulation, which is combined with excessive temperatures, seems to be of disadvantage in such affections, as we have here to deal with a nervous system which has been rendered easily exhausted and hyperirritable by the disease itself. For the same reasons we will also have to exclude all very intense mechanical stimuli in such diseases, unless very definite indications exist for their use.

In accordance with the theory just developed, and with the sanction of a very extensive experience, we will limit ourselves in all chronic diseases of the spinal cord as much as possible to stable temperatures, and to impressions combined with very slight mechanical force. Such temperatures, approaching the point of indifference, are effectual in one instance, by averting irritation; but they also cause a moderate, not spastic but long-continued elevation of the pressure in the vascular system by their temperature — which is below blood-heat — and strengthen the heart, whereby they increase the velocity of the current of the blood in the spinal cord.

In forms and temperatures such as these, the thermal treatment of diseases of the spinal cord will belong to the most effectual measures in our therapeutical treasury. The procedure which I almost exclusively adopt in affections of the spinal cord is the half-bath, allowing its temperature to fluctuate only between the narrow limits of 30° to 20° C. Regarding the duration of each individual half-bath, I allow it to be continued for from six to ten minutes, and no longer.

'In addition to the probably adequate stimulation which the lukewarm water exercises upon the peripheral sensory nerve-endings—and from which very likely moderate and non-exhausting innervating impulses are conducted to the central organ—thermal actions are brought about by direct alterations in the nutritive conditions of the central organ, which place the vaso-motors in a condition of exalted activity, and do not over-stimulate them.'[1]

Only in rare cases of such affections do I apply, after the manner of the French, very short, cool, or cold shower baths the duration of which is at most from a quarter to half a minute. In many cases I observed a favourable influence following the

[1] *Hydrotherapie*, vol. ii. p. 459.

application of excitant compresses to the spinal column in these processes. Greater irritability, and increased lancinating pains, always furnish me with the indication for the use of higher temperatures within the given limits.

There will yet be many a diseased process in which the calling forth of fluxion to the diseased organ will prove itself a powerful curative method.

Fluxion must be considered the most powerful solvent and absorbent that we possess. It is only by way of the circulation that the saturation, solution, and re-absorption of indurated exudations and inflammatory products can be started and carried out. The great number of forms of disease which may find improvement or cure *in fluxion* and *in the fomentation with moist vapour* as accomplished by means of appropriate hydriatic measures, does not, I think, require any detailed enumeration, since, by accurate analysis of nutritive disturbances, it will not be difficult to select cases suitable for this method. I shall therefore limit myself to that which has been already observed relative thereto. Finally, I shall devote a few words to

The Hydriatic Method in General Nutritive Disturbances and Dyscrasic Processes.

Among the large number of diseases under this category are reckoned all those disturbances in which the relation of interchange between the blood and the tissues has undergone an alteration. Every anomaly in the movements of matter, whether in amount, rapidity, direction, or force, and every abnormal constitution of the blood and tissues must lead to general disturbances of nutrition. Even although the balance between supply and discharge in the organism, under numerous physiological and pathological conditions, has been made known to us by numerous accurate investigations, the intermediate links in the chain of our knowledge of metamorphosis of matter in the various organs and tissues, under normal as well as abnormal conditions, are yet almost unknown to us. So long as physiology and pathology do not make us acquainted with the physical and chemical details of all the metabolic alterations in the various acute and chronic diseases, so long

will the therapeutist be limited in his treatment to either indirectly influencing the diseased process, or to setting right such general deviations of metabolism as may be accessible to his operations.

In this respect it will be chiefly the reduction and elevation of the temperature of the body and of the blood, and the stimulation of certain secretions and excretions, through which he will endeavour to gain influence over the constitution of the blood and the whole of nutrition. That which we can rationally accomplish in this direction is comparatively very small. Still there are many important tasks which may here fall to the lot of the thermal, mechanical, and chemical influences of hydrotherapeutics. We need not again enter into those details with which we have become acquainted in earlier sections of this article, concerning the excretion of CO_2 and N, nor again refer to the manner in which reduction and elevation of temperature and the reactionary phenomena following such reductions alter the end products of the organic elemental analysis quantitatively and qualitatively; without again entering into details concerning the alterations of secretions and excretions under the internal and external administration of water, and its effects upon the interchange of matter, I shall only endeavour to show by a few typical examples in what manner the said factors, either alone or in numerous combinations, are capable of fulfilling the indications on hand.

Let us, then, first of all consider the influence of hydrotherapeutics upon an hydræmic condition of the blood and in dropsy. It used to be a fixed and unalterable tradition that the water cure was most strictly contra-indicated in all dropsical conditions. A stencilled water cure ought certainly to be avoided in dropsical conditions, but it is quite different with a method which has endeavoured to adapt itself, as far as possible, to the disturbances of nutrition before it. The general indication in hydræmia, no matter from what organic affection it may have started, will always consist in diminishing the water content of the blood.[1] The most direct manner of accomplishing this apparently consists in increasing the activity of those organs whose duty it is normally to excrete

[1] Vide ante, pp 502-3.

water as much as possible. We must endeavour to increase cutaneous perspiration, the renal excretion, and, under circumstances, the excretion of water by the intestinal canal as well. It will depend upon numerous conditions, whose detailed discussion would here carry us too far, which of these collateral outlets are to be stimulated to increased activity, or whether several of them are to be availed of simultaneously.

The excretion of water by the skin can be increased to any extent desired by stimulating the perspiration; that by the intestine, by active stimulation of the peristalsis through mechanical, chemical, and thermal measures—massage, injections, mineral waters—whilst the renal excretion of water may be increased by a methodically regulated and increased administration of water, by strengthening the heart's action and by elevating the blood pressure. Thirst cures alone will seldom be capable of reducing the watery contents of the blood to any considerable extent—although they might have been *à priori* expected to do so—on account of other disturbances of nutrition which set in, and diminution of all the excretions, including that of water under such a *régime*.

A methodical alternation between an increased supply of water and abstraction thereof, particularly when combined with moderate perspiratory stimulation, operates much more effectually in this direction, and this is corroborated by older as well as modern experimental labours. The water cure will also tend to improve hydræmia by its influence upon nutrition, by increasing transformation and promoting accumulation. The influence which transitory thermal nerve stimulation exercises we have already seen in the tone-giving procedure previously described. The methods to be combined, then, will consist in steam box baths, followed by cold shower baths or moist shampooing; the amount of water lost by the skin, however, must be individually watched during the proceedings. The methodically increased imbibition of water, alternating with abstinence from water for from twelve to eighteen hours, will be often found serviceable. Generally, however, this procedure will only be adopted as an effectual means of support in medical or dietetic therapeutics, during a course of iron or a milk cure for instance.

An extensive field of operation offers itself to hydrotherapeutics *in pathological retardations and accelerations of the metabolism.* Here also we must first of all strive to find the origin, and then remove, if possible, the causes of these metabolic disturbances. For example, if any kind of digestive disturbances—the result of hygienic or dietetic transgression or due to certain organic affections—are discovered, it is only natural that hygienic and dietetic measures should be taken, and that the process should be attacked, medicinally or thermally as the case may be. Sitz baths, abdominal bandages and truncal compresses, applied according to the principles evolved, play an important part in this case. At the same time we shall begin the campaign against the excretion of materials whose elemental analysis has been incompletely carried out—e.g. oxalic acid, uric acid and volatile, bad-smelling cutaneous and oral exhalations—against the diminished excretion of urea, carbonic acid and water, and against the immoderate accumulation of fat, all of which, as we know, are phenomena characteristic of retarded metamorphosis. The thermal nerve stimulation, the reduction of temperature and reactionary temperature elevation—which we have learnt to control at will—will often alter the metabolism in the desired manner, powerfully stimulate the transformation of non-nitrogenous or nitrogenous substances, and allow us to obtain an increase or reduction in the body weight as desired. The therapeutist must himself endeavour to gather details of how to proceed in each individual case, by ascertaining the indications which exist. Where, then, he wishes to bring about a reduction of the body weight, chiefly by means of burning up the fat, he will adopt intense nervous stimuli, moderate perspiratory stimulations, and correspondingly powerful heat abstractions. The procedures which he will select will be wet packings or steam box baths, with consecutive cold whole baths, powerful shower baths and affusions upon the abdomen, especially when he wishes to act upon the latter and the portal circulation, or the movements of the intestines. If accumulation is to be promoted but retrograde change only moderately accelerated, no very profound reduction of temperature need be undertaken, and the nerve stimulus to be

made use of must be adapted to the sensibility to irritation and the exhaustibility of the irritability. Exact hydriatic recipes cannot be laid down either, the existing indications having to be fulfilled in the most varied manner. A *retardation* of the tissue metamorphosis also will be supported by thermal operations. The question here is one of avoiding too intense nerve stimuli and of obtaining a moderate and gradual reduction of the body temperature, whereby too great and too intense reactionary phenomena are avoided. Such procedures as retard the circulation and the action of the heart are therefore to be chosen. Lukewarm temperatures without powerful mechanical irritation, used for a prolonged period—e.g. tepid baths, wet packing in not too cold sheets, and local compresses—are the procedures we will adopt for this purpose.

In order to give another instance of the benefit to be derived from the use of the water cure in dyscrasic processes, we may mention the objects hydrotherapeutics has to fulfil in the treatment of constitutional syphilis. By itself, the water cure perhaps does not cure constitutional syphilis oftener than spontaneous cure is observed to take place. But the combination of an appropriate water cure with antisyphilitic medicinal treatment appears to me to be worthy of consideration.

The objects to be accomplished by hydrotherapeutics in the treatment of lues venerea consist mainly in the influence over the constitution of the blood which it gains by powerfully increasing the watery excretion by the skin, as well as in its influence upon the metabolism, in particular its action in promoting retrograde change and the excretion of retrogressionary products.

In yet another direction will hydrotherapeutics be of service in the treatment of lues; it makes the body more susceptible to the action of the specific medicaments. The combination of hydrotherapeutics with an antisyphilitic cure is of value in the latter respect, since it may be directly proved that the action of medicines under this combination is a more considerable one, even when much smaller doses are given, than without it.

This action of hydrotherapeutics of increasing the effect of medicines, is made comprehensible to us from the fact proved

by Fleury, Maigrot, and others, that medicines which, when administered in small doses by themselves, will not call forth any tonic symptoms, when given simultaneously with water cause extreme medicinal effects, as absorption is promoted and accelerated thereby. We can understand herefrom how it is possible to bring about the cure of a disease with much smaller doses of the specific medicament when administered in this manner than would ordinarily have to be exhibited.

The tonic effects of hydrotherapeutics will further render it possible in many cases in which conditions of great weakness, anæmic phenomena, and diseases of the respiratory organs contra-indicate a thorough antidyscrasic treatment, to yet undertake it in the combination just discussed.

Many an idiosyncrasy and intolerance of specific remedies will also be removed by means of this combination, and during the water cure mercury is said to cause salivation very rarely. It must remain an open question whether this originates from the more rapid excretion of the drug by other collateral channels, until more accurate investigations shall have given us certain data for the subject.

The chief indication for the water cure in the treatment of syphilis consists in the excitation of sweating, to which depurative and spoliative influences on the constitution of the blood are ascribed. Powerful thermal and mechanical cutaneous stimuli, softening, fomenting, macerating and heat-giving procedures, will prepare the skin for increased sweat secretion. The treatment is therefore usually commenced with energetic cold shampooing or shower baths, either with or without antecedent wet packings up to the degree of heat increase, for the duration of from $\frac{3}{4}$ to $1\frac{1}{2}$ hour; steam box baths, with subsequent refrigerations, may here also be applied.

After this preparation we proceed to the sweat-exciting procedures, which will consist in alcoholic vapour baths or in the more energetic dry packings. I usually combine steam box baths with dry packings alternately, according to the urgency of the indication, and on the intermediate days simply allow wet packings lasting from $\frac{3}{4}$ to $1\frac{1}{2}$ hour, with consecutive cold half-baths, to be applied. After the sweat stimulations, intense heat abstractions must always be applied, either in the

form of whole baths, of half-baths at 10° to 16° C., or of cold shower baths.

It is further believed that we possess in hydrotherapeutics a line of treatment which will cause the eruption of latent syphilis. For this reason the water cure is used as a reagent, in order to decide whether the individual in question has been fully purged of the dyscrasia or not. The circumstance that during the application of water cures, syphilis which has been for a long time latent is apt to make new eruptions, does not admit of our absolutely rejecting this view.

Let us once more remind ourselves that *by means of hydriatic interference, innervation and the circulation may be influenced in a very effectual manner*; that the heat processes—both production and discharge—may be well-nigh voluntarily controlled; that the secretions and excretions, processes of nutrition and tissue metabolism may be accelerated or slowed, and also altered, in a definite manner. If now we endeavour to generalise the few examples which I attempted to instil in the last section, it must be granted that rational indications may be found for hydriatic treatment in various nutritive disturbances and the sundry forms of disease.

An attempt has been made to show the intimate relations between the therapeutical actions of water and the physiological actions which take place during thermal and mechanical impressions made upon the organism.

That this basis, which is the same for the whole of therapeutics, is for the present state of our relative knowledge neither sufficiently broad nor sufficiently deep, has not been concealed.

The gaping deficiencies in our knowledge—which exist in this as well as in every other branch of therapeutics—will still require incalculable labour to fill up. It will perhaps be a more powerful stimulus to fill them in rapidly, if we know that the practical results have got far in advance of their theoretical foundation.

It has been my most zealous endeavour to give the start to investigation in many a new direction on this as yet but little explored territory.

TABLE COMPARING THE SCALES OF THE FAHRENHEIT AND CENTIGRADE THERMOMETERS.

Cent.	Fahr.	Cent.	Fahr.
100°	212°	55°	131°
99	210·2	54	129·2
98	208·4	53	127·4
97	206·6	52	125·6
96	204·8	51	123·8
95	203	50	122
94	201·2	49	120·2
93	199·4	48	118·4
92	197·6	47	116·6
91	195·8	46	114·8
90	194	45	113
89	192·2	44	111·2
88	190·4	43	109·4
87	188·6	42	107·6
86	186·8	41	105·8
85	185	40	104
84	183·2	39	102·2
83	181·4	38	100·4
82	179·6	37	98·6
81	177·8	36	96·8
80	176	35	95
79	174·2	34	93·2
78	172·4	33	91·4
77	170·6	32	89·6
76	168·8	31	87·8
75	167	30	86
74	165·2	29	84·2
73	163·4	28	82·4
72	161·6	27	80·6
71	159·8	26	78·8
70	158	25	77
69	156·2	24	75·2
68	154·4	23	73·4
67	152·6	22	71·6
66	150·8	21	69·8
65	149	20	68
64	147·2	19	66·2
63	145·4	18	64·4
62	143·6	17	62·6
61	141·8	16	60·8
60	140	15	59
59	138·2	14	57·2
58	136·4	13	55·4
57	134·6	12	53·6
56	132·8	11	51·8

Table comparing Fahrenheit and Centigrade Thermometers—continued.

Cent.	Fahr.	Cent.	Fahr.
10°	50°	20°	4°
9	48·2	21	5·8
8	46·4	22	7·6
7	44·6	23	9·4
6	42·8	24	11·2
5	41	25	13
4	39·2	26	14·8
3	37·4	27	16·6
2	35·6	28	18·4
1	33·8	29	20·2
Zero	32	30	22
1	30·2	31	23·8
2	28·4	32	25·6
3	26·6	33	27·4
4	24·8	34	29·2
5	23	35	31
6	21·2	36	32·8
7	19·4	37	34·6
8	17·6	38	36·4
9	15·8	39	38·2
10	14	40	40
11	12·2	41	41·8
12	10·4	42	43·6
13	8·6	43	45·4
14	6·8	44	47·2
15	5	45	49
16	3·2	46	50·8
17	1·4	47	52·6
18	——	48	54·4
19	2·2	49	56·2

Zero Fahrenheit corresponds with *minus* 17·78 C.

NOTE.—As it may be desirable to see at a glance the equivalent in Fahrenheit's scale to the degrees Centigrade, as used throughout Dr. Winternitz's work, the Translator has thought it might not be out of place to insert a table, based on the very fair comparisons given in *Whitaker's Almanack*, at the end of the essay. The day is, of course, not very far distant when the much less complicated metric system will be in general use in the British Isles also; but in the meantime it is rather a little too circumstantial to mentally convert degrees C. into degrees F. by means of the formula

$$\frac{°C \times 9}{5} + 32 = °F.$$

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